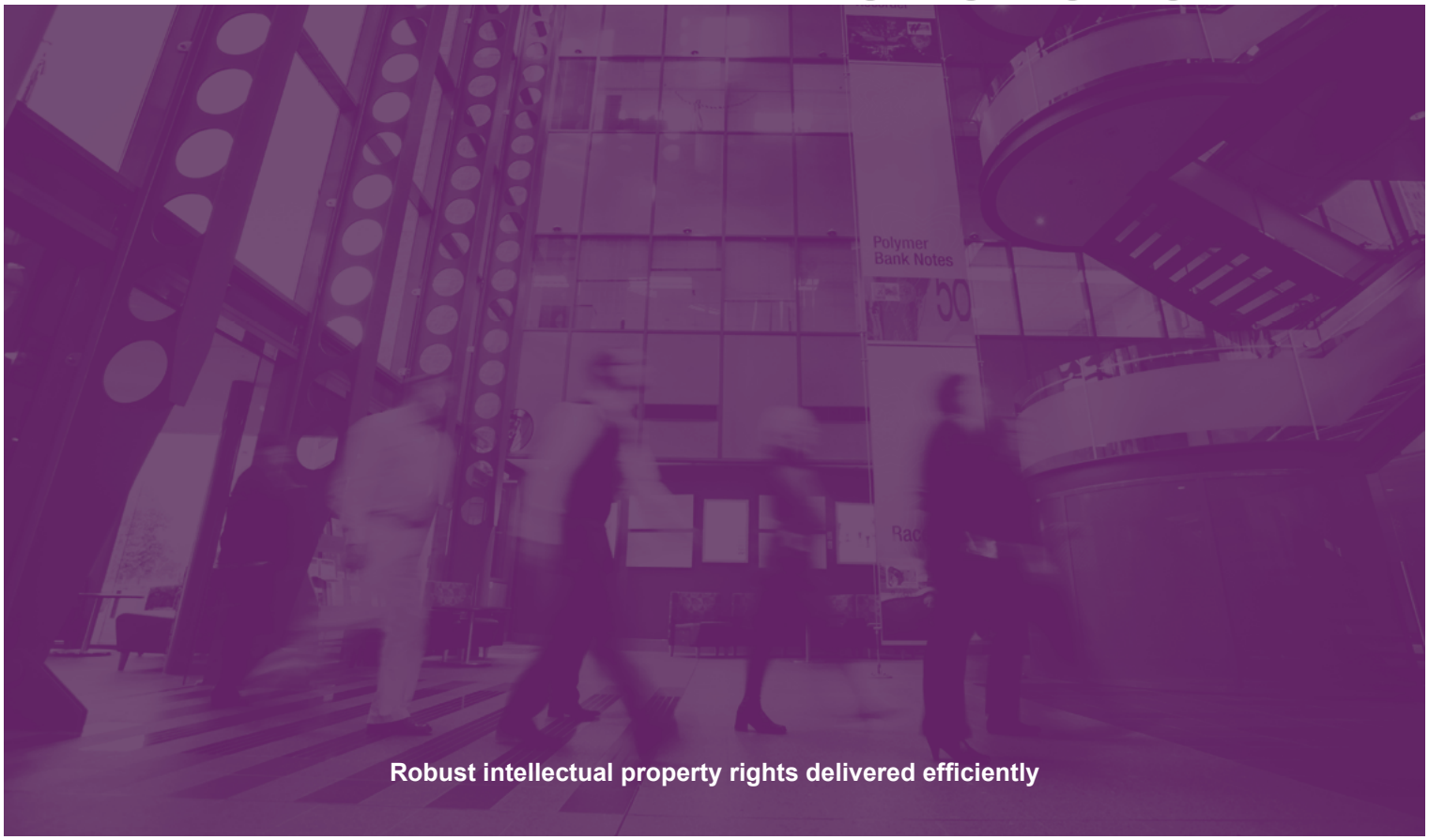
Australian Government
Department of Industry
IP Australia

Australian Medical Devices: A Patent Analytics Report

2014



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The information contained in this brief has been gathered from global IP databases and represents a snapshot of patenting data in medical devices at a particular point in time. It is provided for general information only and should not be relied upon for the purposes of any particular matter. It is not a report on patentability or freedom to operate and should not be relied upon for those purposes.

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Executive summary

The global medical devices market is valued at approximately US$325 billion. In 2012, the Australian industry had turnover of $10 billion, with exports of over $2.1 billion in 2013–2014. The medical devices industry comprises a variety of entities that engage in innovation and manufacturing including individuals, academic institutions and public research organisations, small and emerging companies, and large multinational corporations.

This report provides insights into the technological innovation of the domestic med tech sector through an analysis of the scope, quality and impact of Australian-originated patents. The results indicate Australia's relative importance in innovative activity in medical devices.

The study identifies 2706 medical device inventions that originate from Australia between 2001 and 2012. Australia ranks 13th in medical device patents globally, comparable to China and the Netherlands.

Australia exhibits a positive technological specialisation in the medical devices industry, which means that the share of medical device patents filed by Australian inventors is more than the overall proportion of medical device patents filed worldwide.

Australia ranks eighth in technological specialisation globally, comparable to Switzerland and New Zealand, and is one of a few countries with a positive technological specialisation. Within Australia, the majority of inventions (44 per cent) originate in New South Wales.

The top three applicants, ResMed, Cochlear and Cook, contribute to almost 20 per cent of the total inventions filed in the medical devices field. These applicants are corporations with a focus on research, production and sale of products in very specialised areas of technology: Respiratory (ResMed), Hearing (Cochlear) and Stents (Cook). The Respiratory and Hearing fields show growth over the study period. Stents show a decline in activity due to the lack of new entrants and the decline in activity by Cook, who is the dominant applicant in this area.

The technology sub-fields with the most inventions are Surgical and Electromedical/ Diagnostics. In addition to these, Implants and Vision show growth in activity over the study period.

The number of citations a patent receives is positively related to its economic value. Areas of high impact, in which the average number of citations that an invention receives is higher than the worldwide average, include the Electromedical/ Diagnostics, Implants, Respiratory, Stents and Surgical fields. A number of the top-cited inventions also fall within these fields.

While many companies specialise in one sub-field of medical devices, research by CSIRO and the universities is diverse and encompasses the whole field. CSIRO and the universities are also the most prominent collaborators in the area. In particular, the University of Technology, Sydney, the University of Sydney, the University of Queensland and the University of Melbourne are the dominant collaborating universities. In addition, research organisations and SMEs collaborate more than big corporations.

In terms of international collaborations, around 18 per cent of Australian-originating inventions have collaboration with a foreign inventor and around 16 per cent of Australian-originating inventions are owned, or partly owned, by foreign companies.

The top destinations for pursuing patents are the United States, Australia, Europe, Japan, China and Canada. This suggests that they are favourable jurisdictions for intellectual property rights and favourable markets for medical device products.

1. Objectives and methodology

This report analyses medical device inventions originating in Australia. It identifies how patent activity, technological specialisation and collaboration can help to illustrate the innovation landscape. This report uses patent analysis to assess the scope, quality and impact of innovative activity within the medical devices sector.

1.1 Objectives

The key objectives of this report are to:

1. Determine the scale and intensity of patenting activity in medical devices originating from Australia and its subregions;
2. Assess the level of collaboration in medical device innovations;
3. Evaluate the quality of Australian patenting activity in medical devices; and
4. Identify target markets for Australian-originated inventions relating to medical devices.

1.2 Patents as indicators of research performance

Patents can be used as indicators of R&D output.[1] A patent is a right that is granted for any device, substance, method or process that is new, inventive, and useful. Patent rights are legally enforceable and give the owner exclusive rights to commercially exploit the invention for a limited period of time.

It is a requirement of patent law that patent documents are published and that they fully disclose inventions. As a result of the disclosure requirement, patent literature reflects developments in science and technology. Patent documents include other useful information, such as international patent classifications and information about inventors and applicants.

Through the extraction and analysis of data associated with patent documents, it is possible to measure aspects of inventive activity such as scope, intensity, collaboration and impact. These metrics can be developed across technology sectors and by various units of measurement, such as individuals (inventors), institutions (applicants), regions and countries.

1.3 Definition of Australian medical device patents

There are two major filing routes for patent applications: international and direct.

The international route involves filing a Patent Cooperation Treaty (PCT) application, which establishes a filing date in all 148 contracting states. A PCT application must be followed by entering into national or regional phase to proceed towards grant.[2]

The patent documents of Australian origin will be identified by inventor address for international applications filed under the PCT. Patent documents filed outside the PCT system will not be considered in this study.

[1] For example, see Griliches, Z. (1998) Patent Statistics as Economic Indicators: A Survey, R&D and Productivity: The Econometric Evidence, University Chicago Press.

[2] For each of the contracting states to the PCT, see Appendix F. The PCT is intended to streamline the initial filing process for those applicants who intend to seek protection for their invention in multiple jurisdictions.

1.4 Identification of medical device patents

For the purposes of this report, medical devices are defined as:[3]

(a) any instrument, apparatus, appliance, material or other article (whether used alone or in combination, and including the software necessary for its proper application) intended, by the person under whose name it is or is to be supplied, to be used for human beings for the purpose of one or more of the following:

> *(i) diagnosis, prevention, monitoring, treatment or alleviation of disease;*
>
> *(ii) diagnosis, monitoring, treatment, alleviation of or compensation for an injury or disability;*
>
> *(iii) investigation, replacement or modification of the anatomy or of a physiological process;*
>
> *(iv) control of conception;*
>
> *and that does not achieve its principal intended action in or on the human body by pharmacological, immunological or metabolic means, but that may be assisted in its function by such means; or*

(b) an accessory to such an instrument, apparatus, appliance, material or other article; or

(c) veterinary devices.

[3] Per the Therapeutic Goods Act 1989. Note the scope is extended to include veterinary devices for the purposes of this report.

1.5 Timeframe for analysis

Patents with a priority date between 1 January 2001 and 31 May 2012 were used in this analysis.

The priority date is the most relevant for ascertaining the date of invention. It is the earliest date recorded on patents and therefore allows the comparison of dates unaffected by administrative variations or delays.[4]

1.6 Classification of inventions

Patent documents contain an International Patent Classification (IPC) that classifies the invention(s) disclosed in the patent. The IPC was used as a primary categorisation tool for the technology areas in this study, and the primary search was conducted using these marks (Appendix A and Appendix B).[5]

The IPC classifies technology areas into 70 000 different IPC codes. While some of the IPC classifications have descriptions that readily correspond with medical device technologies, many do not. Therefore, IPC classes were correlated with keywords from the Australian and New Zealand Standard Industrial Classification (ANZSIC) Classes 2411[6] and 2412[7] and used to further breakdown the search results in to relevant categories (see Appendix E).

[4] The October 2013 edition of the PATSTAT database used for creating the January 2014 edition of the REGPAT database identifying PCT applications contains all publications to the end of November 2013, essentially comprising publications with a priority date up to May 2012. Some documents with later priority dates are published earlier than 18 months after the priority date and are in the database.

[5] This classification allows countries to class patents under a common system, which facilitates searching and a direct comparison between technologies and between countries. For more information about the IPC system see http://www.wipo.int/edocs/mdocs/classifications/en/ipc_ce_41/ipc_ce_41_5-annex1.pdf

[6] Class 2411 Photographic, Optical and Ophthalmic Equipment Manufacturing: http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/1D2D8AE15AD5FB1ECA257B9500133C75?opendocument

[7] Class 2412 Medical and Surgical Equipment Manufacturing: http://www.abs.gov.au/AUSSTATS/abs@.nsf/0/D8AA952974A7D82CCA25711F00146F8F?opendocument

1.7 Data extraction and analysis

There were four key stages of data extraction and analysis.

The first stage involved identifying the relevant technology areas (as determined from IPC and keyword searches) and the PCT applications relating to medical devices originating from Australia between 2001 and 2013.

The patent families of the PCT applications were then established — documents generally relating to the same invention but filed in different countries. Patent families enable us to analyse inventive activity regardless of the number of countries in which protection is sought.

EPO Worldwide Patent Statistical Database (PATSTAT)[8] and REGPAT produced jointly by the Organisation for Economic Co-operation and Development and the European Patent Office, were used to identify Australian-originated PCT applications. Derwent World Patent Index (DWPI), developed by Thomson Reuters, covers patent records from 47 jurisdictions, including Australia. It was used for retrieving additional data fields. Refer to Appendix A for details of the search strategy and Appendix B for details of the IPC marks used in the search.

The OECD subregion definitions were used to identify the geographic locations of patenting activity within Australia. States and Territories are linked with PCT data according to the address of the patent applicant and inventor.

The second stage was data cleansing, such as eliminating duplicate records, identifying subsidiaries of parent companies, screening for spelling variation, and checking for genuine Australian derived inventions.

The third stage was classifying data and eliminating irrelevant records.

The final stage comprised data analysis, including the calculation and visual presentation of patent metrics.

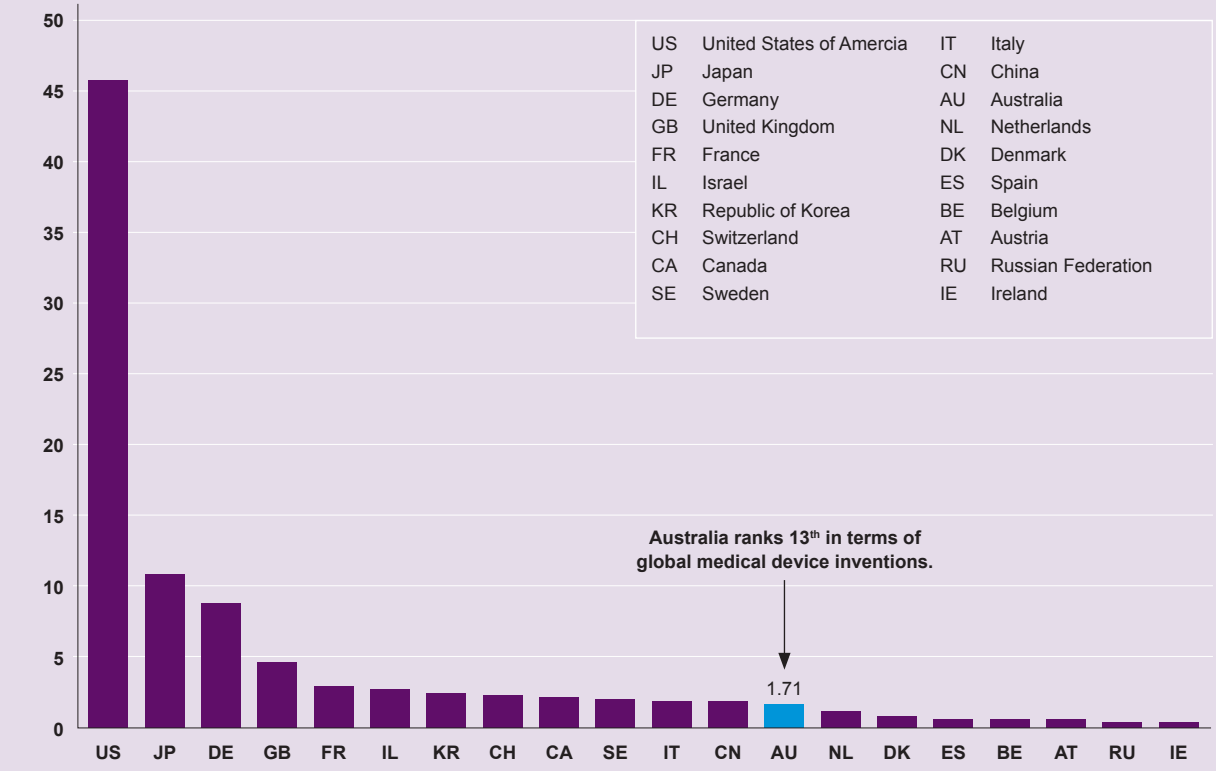
[8] April 2014 edition of the PATSTAT database

2. Patenting scale and technological specialisation

2.1 Patenting scale and intensity

This study identified 139 170 PCT applications (inventions) filed in the medical devices area worldwide with a priority date between 2001 and 2012 of which 2706 had at least one Australian inventor. Australia generated around two per cent of the global medical device inventions, based on inventor participation, and ranks 13th worldwide, comparable with China and the Netherlands (Figure 1). Co-inventorship (inventors from multiple countries) is accounted for by using inventor shares. The United States dominates patenting activity in this area with nearly half the PCT applications in the medical devices area having an inventor from the United States.

Figure 1: Share of medical device inventions across the top 20 countries (%)



Source: OECD, REGPAT database, January 2014

2.2 Patenting activity over time

In this section the metric of interest is the priority year as this is the year of first filing of a PCT application and hence closest to the actual date of the invention. An application filed under the PCT at the international phase allows for an applicant to file pre-applications to many offices world-wide. Subsequent prosecution at the national phase before individual patent offices is made at the discretion of the applicant.

The numbers of medical device PCT applications filed by Australian inventors based on the earliest priority year is shown in Figure 2. A steady increase in applications over 2001 to 2006 was followed by a dip in 2007, and decline after 2008. The reduced numbers may reflect the effects of the global financial crisis and reduced industry spending. (Data for 2012 is incomplete as PCT applications are published 18 months after filing.)

Figure 2: Australian-originating PCT applications by priority year

Source: OECD, REGPAT database, January 2014

2.3 National relative technological specialisation

The Relative Specialisation Index (RSI) is calculated as a correction to absolute numbers of patents in order to account for the fact that some countries file more patent applications than others in all fields of technology. In particular, inventors in the United States and Japan are prolific patentees. The RSI compares the fraction of patents originating from each country in the technology area to the fraction of patents originating from that country overall. A logarithm is applied to scale the fractions more suitably.

The formula is given below:

$$RSI = \log_{10}\left(\frac{n_i / n_{total}}{N_i / N_{total}}\right)$$

where:

n_i = number of *medical device* patents from country *i*

n_{total} = total number of *medical device* patents in dataset

N_i = total number of patents from country *i*

N_{total} = total number of patents in dataset

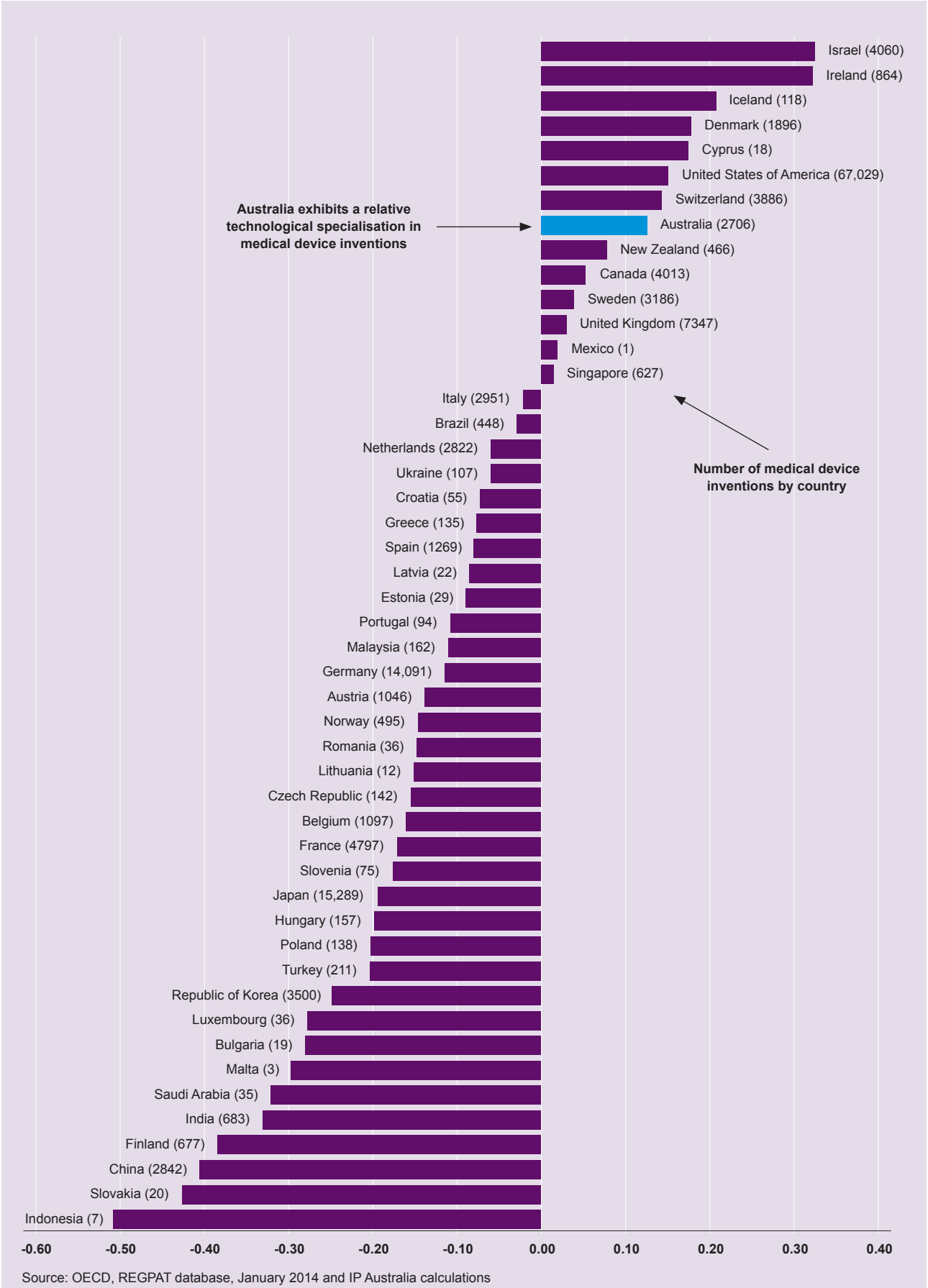
The effect of this is to highlight countries which have a greater level of patenting in the searched area than expected from their overall level of patenting, and which would otherwise languish much further down in the lists, unnoticed.

In this study, the RSI is based on patent applications filed under the PCT and the country's share of 139 170 PCT applications in the medical devices technology field divided by the country's share in all patents. The index can also be calculated at a regional level (in this case, state or territory) as an indicator of a region's relative technological specialisation (see section 2.4). To calculate the RSI at the state level, we replace country in the above equation with the state or territory of interest.

The index is equal to zero when the country's share in a given technology field is equal to all patents filed in all fields (no specialisation), and positive when a specialisation is observed.

Figure 3 shows the RSI values by country. Values above zero indicate a specialisation. Australia is one of a few countries that exhibit a relative technological specialisation in medical devices.

Figure 3: Relative Specialisation Index and number of medical device inventions, by country



Source: OECD, REGPAT database, January 2014 and IP Australia calculations

2.4 Inventive activity by Australian states and territories

The technological specialisation can be further broken down to the regional level. Figure 4 plots specialisation and distribution of medical device patenting activity by state and territory. These are PCT applications in medical devices with at least one Australian inventor. Co-inventorship and co-ownership (inventors from multiple states or territories) are accounted for by using inventor and applicant shares.[9]

The majority of inventions in this technology originate from New South Wales (1200 inventions based on inventor share), followed by Victoria (504) whose contribution is less than half of New South Wales, with Queensland claiming third place (297) (Figure 4(a)).

A similar map based on applicant share is illustrated in Figure 4(b). The difference in numbers between inventor shares and applicant shares is indicative of the fact that inventors and applicants collaborate across state and country boundaries. This data correlates with the 2013 report of the Medical Technology Association of Australia Limited which allocates the location of the majority of medical technology companies in Australia to New South Wales (55 per cent), followed by Victoria (24 per cent) and Queensland (12 per cent).[10]

It is also possible to calculate a corrective specialisation index for Australian states and territories which takes into account the fact that some states may generally be more prolific patent filers irrespective of technology. This index referred to in this report as a State Comparative Advantage, wherein:

$$\textit{State comparative advantage} = \frac{n_i / n_{total}}{N_i / N_{total}}$$

n_i = number of medical device patents from state *i*

n_{total} = total number of medical device patents in Australia

N_i = total number of patents from state *i*

N_{total} = total number of patents in Australia

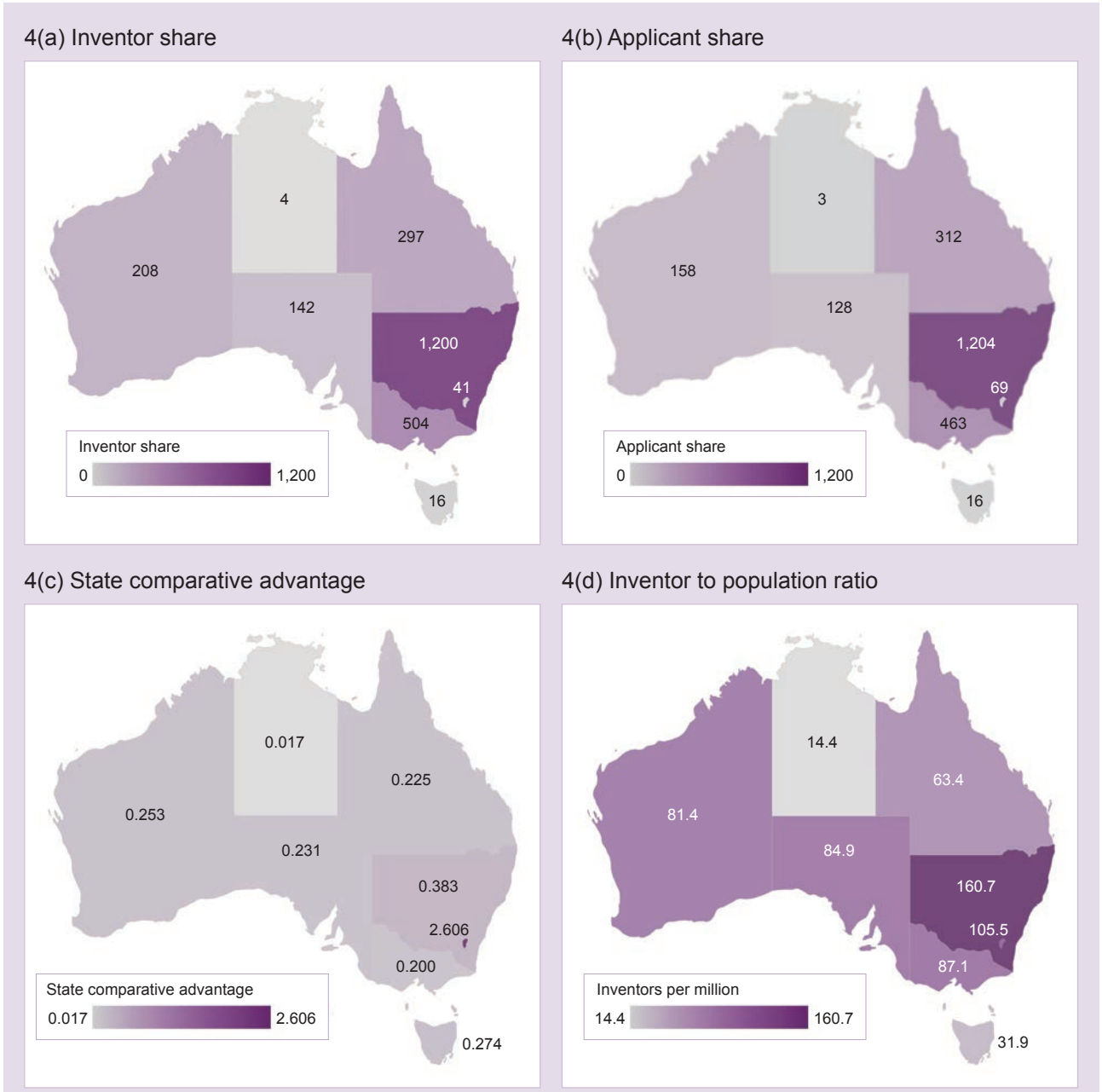
The State Comparative Advantage has been graphed in Figure 4(c), illustrating that only the ACT shows specialisation in the medical devices area, with a State Comparative Advantage of 2.606, even though only 41 inventions originated in the ACT. All other states and territories do not show specialisation.

To further account for varying population densities among the states and territories, population statistics were incorporated into a calculation to complete the inventor activity profile. Figure 4(d) illustrates an inventor per million population ratio which again identifies New South Wales (160) as a hot spot of inventive activity followed by the ACT (105). Victoria, South Australia and Western Australia have approximately 80–90 inventors per million in this technology.

[9] The REGPAT database contains classification codes corresponding with AU states and territories that were derived from the recorded inventor addresses associated with the PCT application. See OECD Measuring Innovation: a New Perspective, 2010, p.34. http://www.oecd.org/site/innovationstrategy/45186706.pdf

[10] Medical Technology: Key facts and figures 2013, Medical Technology Association of Australia. http://www.mtaa.org.au/docs/key-documents/mtaa-factbook-2013-final.pdf?sfvrsn=0

Figure 4: Specialisation and distribution of medical device PCT applications by state



Source: OECD, REGPAT database, January 2014. Australian Demographic Statistics, December 2013 (cat. no. 3101.0)

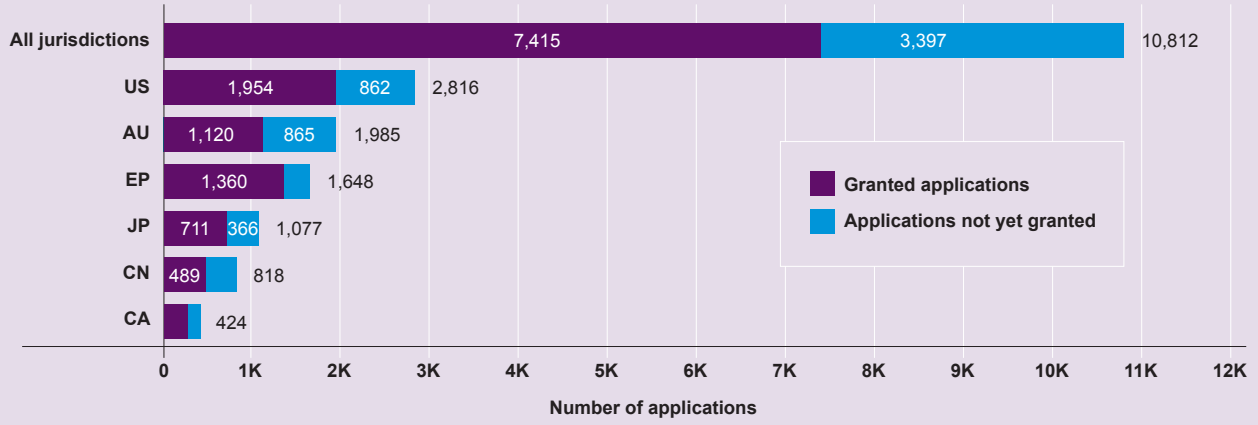
3. Target markets

A PCT application can be further prosecuted at the national or regional level resulting in patent families. Individual patents which are then prosecuted within these countries are then known as 'national phase' applications. In this data set the total number of national phase applications was 10 812 (this may include divisionals and other types of continuing applications) and the total number of grants resulting from prosecution of these applications was 3,397 across all jurisdictions (Figure 5). The countries of most prevalent national phase entry and the grants resulting from these family members have been illustrated. The predominant jurisdiction of national phase entry is the United States, followed by Australia, the European Union, Japan, China, and Canada.

The fact that more applicants choose to prosecute their inventions in these jurisdictions is an indication of favourable markets for medical device products in these countries and the prevalent attitude of that jurisdiction to intellectual property rights.

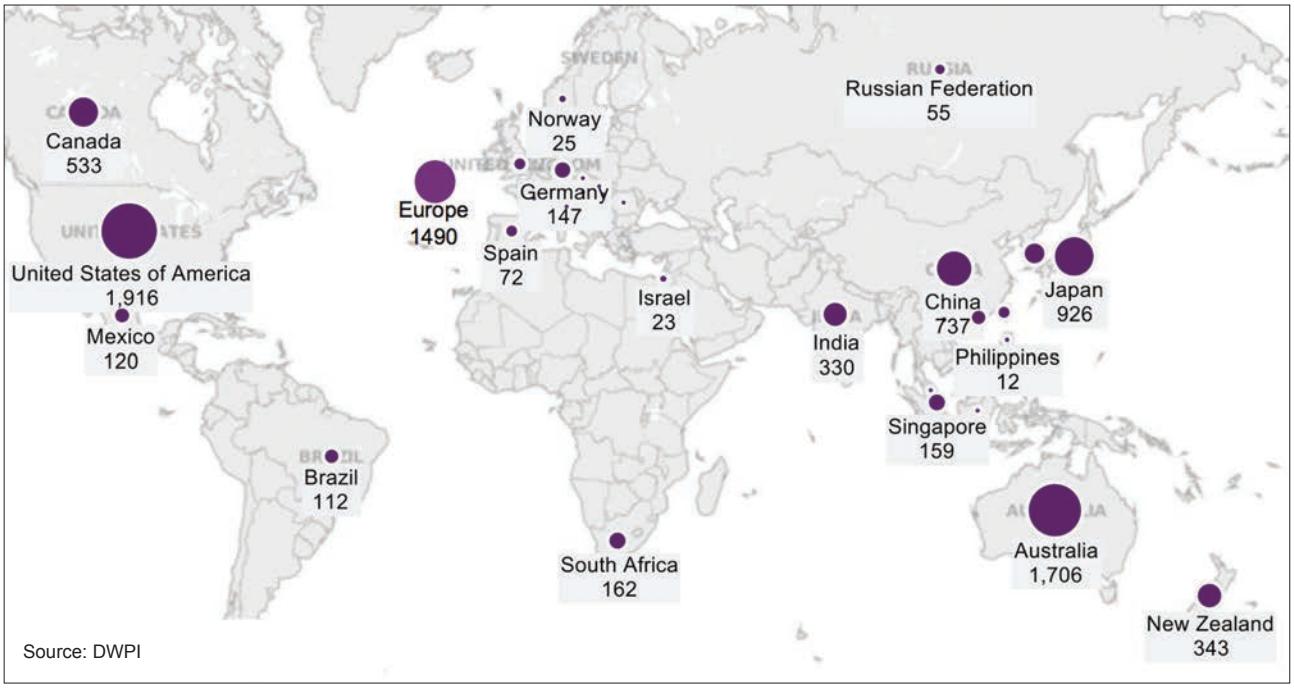
An application with many family members is considered to be valuable as the applicant has had to invest in filing in many national jurisdictions. In this data set the PCT application with the most family members is WO 2011/156835, assigned to Silverbrook and directed to a module for molecular diagnostic testing to detect inherited and acquired disorders using a photosensor output signal to generate a spectrogram.

Figure 5: Applications and grants resulting from national phase entry of medical device applications



Source: DWPI

Figure 6: Geographic filing breadth



One indicator of potential target markets is the geographical filing breadth of patent families where applicants have actively pursued their inventions. A plot of the family members associated with the PCT applications analysed within the time period across the globe allows for identification of potential markets and is illustrated in Figure 6.

The medical devices field has a world market as is self-evident from the map. The US and Europe dominate the commercial market but there may also be an emerging market in Asia. The European Patent Convention provides a legal framework for the granting of European patents by a single, harmonised procedure. Once a European patent is granted, it comes into existence as a group of national patents in each of the designated Contracting States.

The markets identified based on family member applications can be further validated through the associations identified among applicants in a given area of technology using Aduna cluster maps. In almost all the technology specialisations it is possible to identify a collaborator who is not based in Australia. This is most evident in the areas of Surgical, Implants and Stents (see sections 7.4, 7.5 and 7.3). Where international collaborations exist, the country of the foreign collaborator is viewed as a potential target market.

Some medical devices have markets in first world countries with aging populations and a high standard of living whist other devices have a more broad application because in any given population a certain percentage of people will be afflicted with the ailment such as Type 1 diabetes. Asian markets have also been identified as having potential with a rising growth in the middle class. As the value of intellectual property is viewed differently in some Asian countries there is often a risk associated with inventing in these markets. The Australian Government has recently awarded a grant to AusBiotech to conduct research on a project aimed at delivering Australian Medical Devices and Diagnostics to China.[11]

[11] Lavelle, A. 'Australian medical devices seeking new markets in Asia', Australian Life Scientist, 10 December 2013, http://lifescientist.com.au/content/biotechnology/article/australian-medical-devices-seeking-new-markets-in-asia-47943919

4. Degree of collaboration within Australia and internationally

4.1 Inventorship collaboration

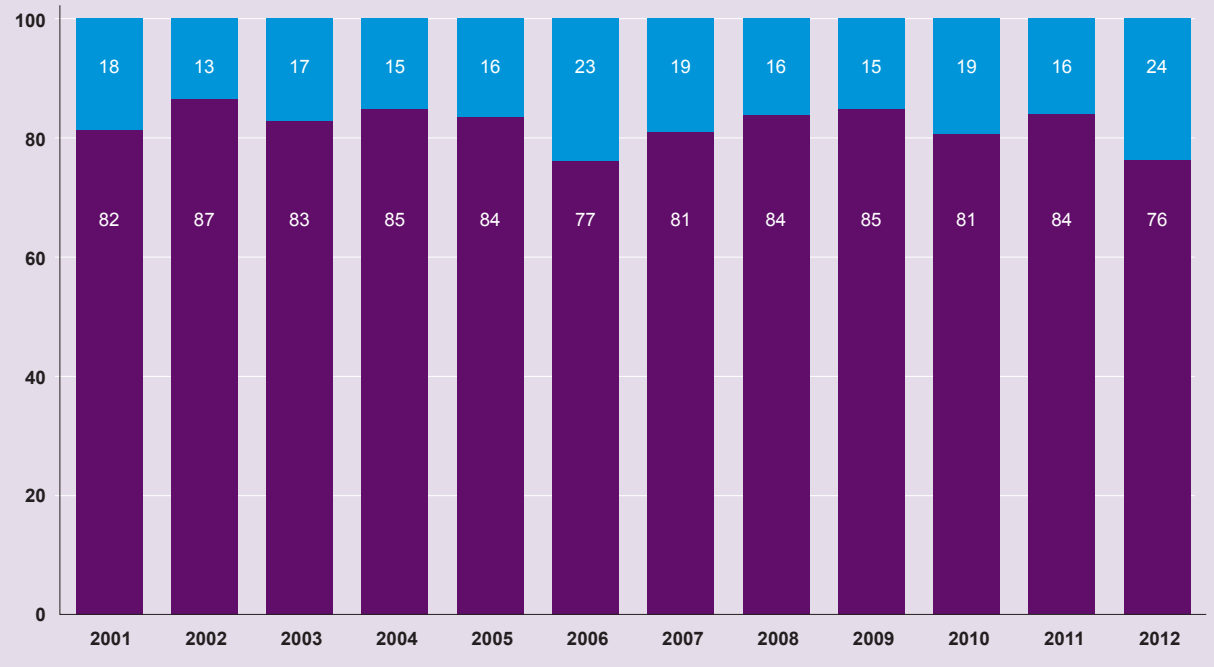
There has been a steady level of collaboration between Australian and foreign inventors over the study period (Figure 7). The share of Australian inventions involving a foreign inventor has ranged between 13 and 24 per cent.

Collaborations were identified with the inventor field of the PCT applications. The inventor share was allocated based on the address (domestic or international).

International collaboration by AU inventors spans 35 countries, and is most prevalent with the US, UK and Germany (Table 1).

As the definition of an Australian-originating invention is one with an Australian inventor, it follows that all 2,706 applications have an Australian inventor contributing to them.

Figure 7: Inventor origin, by priority year (%)



Source: OECD, REGPAT database, January 2014

Table 1: Top sources of international collaboration for AU inventors

Country	Number of applications involved in
Australia	2,706
United States of America	248
United Kingdom	65
Germany	47
New Zealand	26
Switzerland	21
Denmark	15
China	14
Sweden	13
Canada	12
France	11
Netherlands	10
Russian Federation	10
Belgium	9
Singapore	9
Italy	7
Ireland	5
Malaysia	5

Source: OECD, REGPAT Database, January 2014

4.2 Ownership (applicant) collaboration

Another way of looking at international collaboration is with ownership/applicant data.

Again, the most prevalent collaborators are in the US, followed by the UK, Switzerland and Germany (Table 2).

The countries which collaborate with Australian inventor and applicants are potential foreign markets for Australian medical devices.

Table 2: Top sources of international collaboration for AU applicants

Country	Number of applications involved in
Australia	2,374
United States of America	263
United Kingdom	46
Switzerland	29
Germany	27
New Zealand	12
China	13
France	11
Austria	7
Denmark	14
Belgium	5
Canada	6
Singapore	4
Barbados	3
Sweden	3
Japan	3

Source: OECD, REGPAT Database, January 2014

5. Key patent applicants

There were 1,441 distinct applicants associated with PCT applications in the medical devices field (noting that this number includes co-applicants). Only 360 of these applicants had filed two or more PCT applications. In other words 1,081 applicants had filed only one PCT application and are 'single filers'. Single filers represent 40 per cent of PCT medical device applications.

5.1 Applicant categories

The list of distinct applicants includes not only companies, but also individuals who have either filed privately or whose name appears as a co-applicant on a PCT application. A count of the 'private inventor/co-applicant' assignees identified 459 individuals (Table 3).

Table 3: Applicants by applicant type

Applicant category	Number of applicants
Inventor/Co-applicant	459
Research	105
Big	83
SME	81

Source: DWPI

Ressearch organisations include universities, publicly funded research organisations (PFROs) and CSIRO. Entities classified as a PFRO are those that receive public funding. Although CSIRO and the universities are a part of this heading they have been treated separately in this report as they represent filings in multiple areas of specialisation.

Furthermore, some applicants were able to be categorised by the size of the company into either a Big entity or a small or medium enterprise (SME). The definition of an SME used here is the ABS definition of a business which employees less than 200 people.[12] SMEs and Big companies were identified using the US Patent Grant Maintenance Fee Events File[13] using either the corresponding US grant number or by comparing a list of entities in the file with entities filing under the A61 IPC mark in DWPI. Other Big companies were identified in a database produced for internal IP Australia use by the University of Melbourne that compared the ABNs and ACNs of Australian patent applicants against a subsidiary-parent list acquired from Wharton/Bureau van Dijk and the Australian Business Database.[14] Universities were removed from both the Big and SME categories and given their own category to account for the different definitions given to universities in the three databases used. Using the business size databases available to us, we were able to identify 83 applicants as Big entities and 81 companies as SMEs.

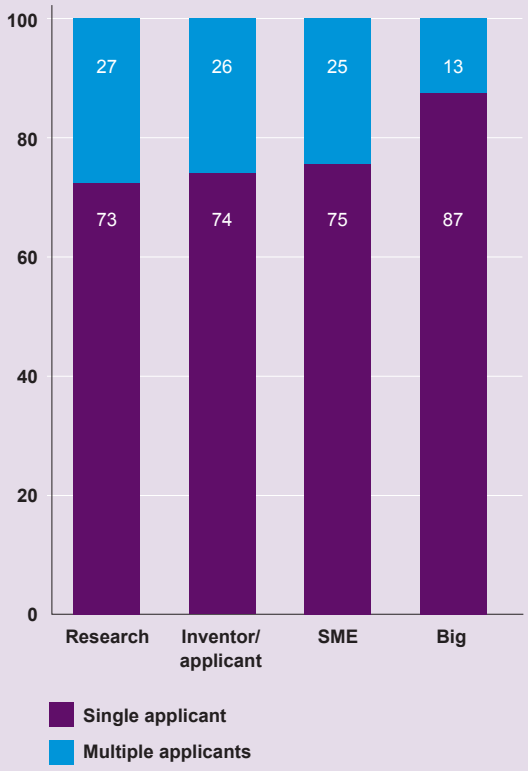
[12] Small Business in Australia, 2001 http://www.abs.gov.au/ausstats/abs@.nsf/mf/1321.0

[13] US Patent Grant Maintenance Fee Events File https://www.google.com/googlebooks/uspto-patents-maintenance-fees.html

[14] Australian Business Database www.screechmedia.com

Figure 8 illustrates the proportion of PCT applications in each applicant category that results from a collaborative effort. For instance, 27 per cent of patent applications by research entities involve collaboration compared to 13 per cent of patent applications by large corporations. Overall, applicants in the research field, private inventor/co-applicants and SMEs collaborate about twice as much as large corporations.

Figure 8: Share of PCT applications with more than one applicant, by applicant type



Source: DWPI

5.2 Patent landscape analysis

To give a snapshot of the overall landscape of Australian-originated medical device inventions, a patent map provides a visual representation of the patents. A ThemeScape map is generated using Thomson Innovation software. Patents are grouped into peaks according to the occurrence of keywords in the title and abstract, and examples of the highly reoccurring keywords appear on the map (Figure 9).

The more closely related the patents and the more concentrated the key words, the higher the topography on the map, as shown by the contour lines.

The top applicants work in the following areas of specialisation: ResMed – respiratory masks, Cook – stents, and Cochlear – hearing implants (Figure 9). Australia is specialised in syringes, eye- and lens-related inventions, implants and orthopaedic devices, catheters, dental, imaging/computer-related medical innovations, and cardiac-related inventions. The specialisations attributable to these areas are based on the cumulative contributions of many applicants outside of top applicants. These specialisations are among those used in the ecosystem development in section 6.

The contribution of CSIRO and the Universities are not clustered on the map and are dispersed across the landscape.

The top 10 inventors can be identified in the ThemeScape map further illustrating associations between technology specialisations and inventors (Figure 10).

Figure 9: Australian medical devices patent landscape (Source: Thomson Innovation)

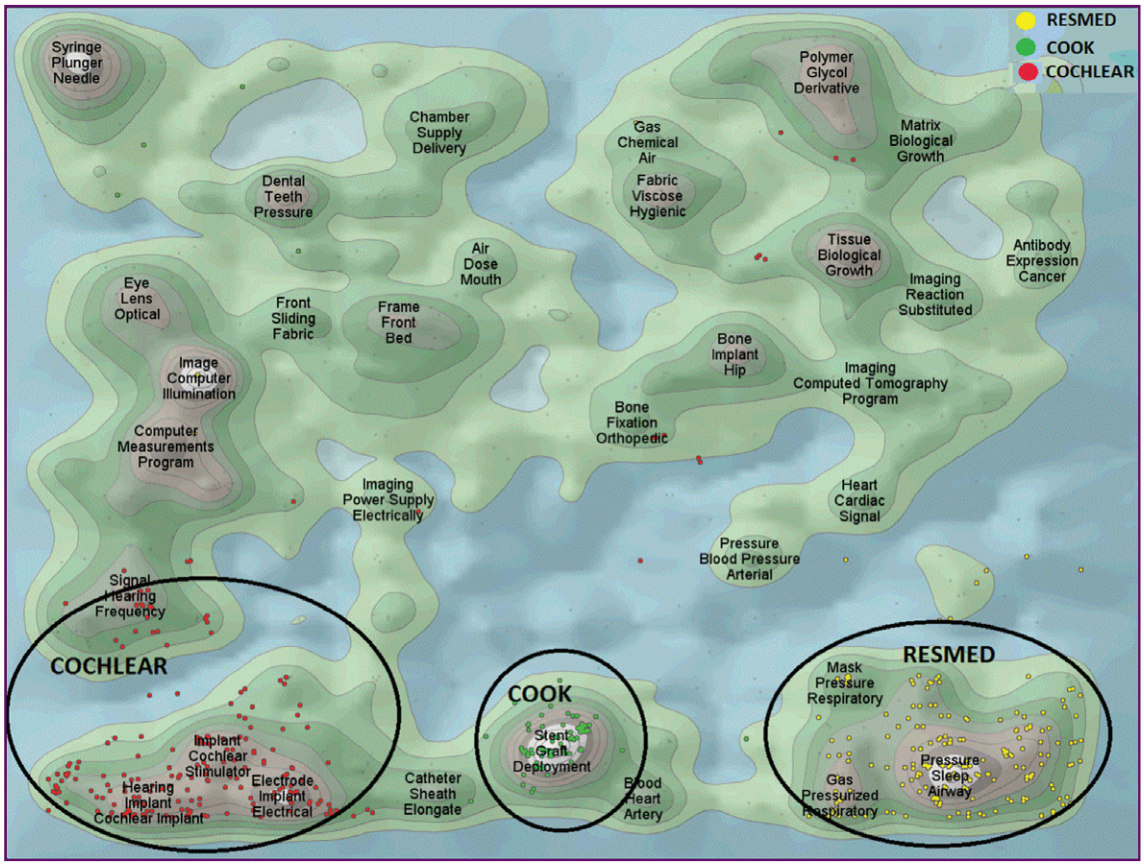
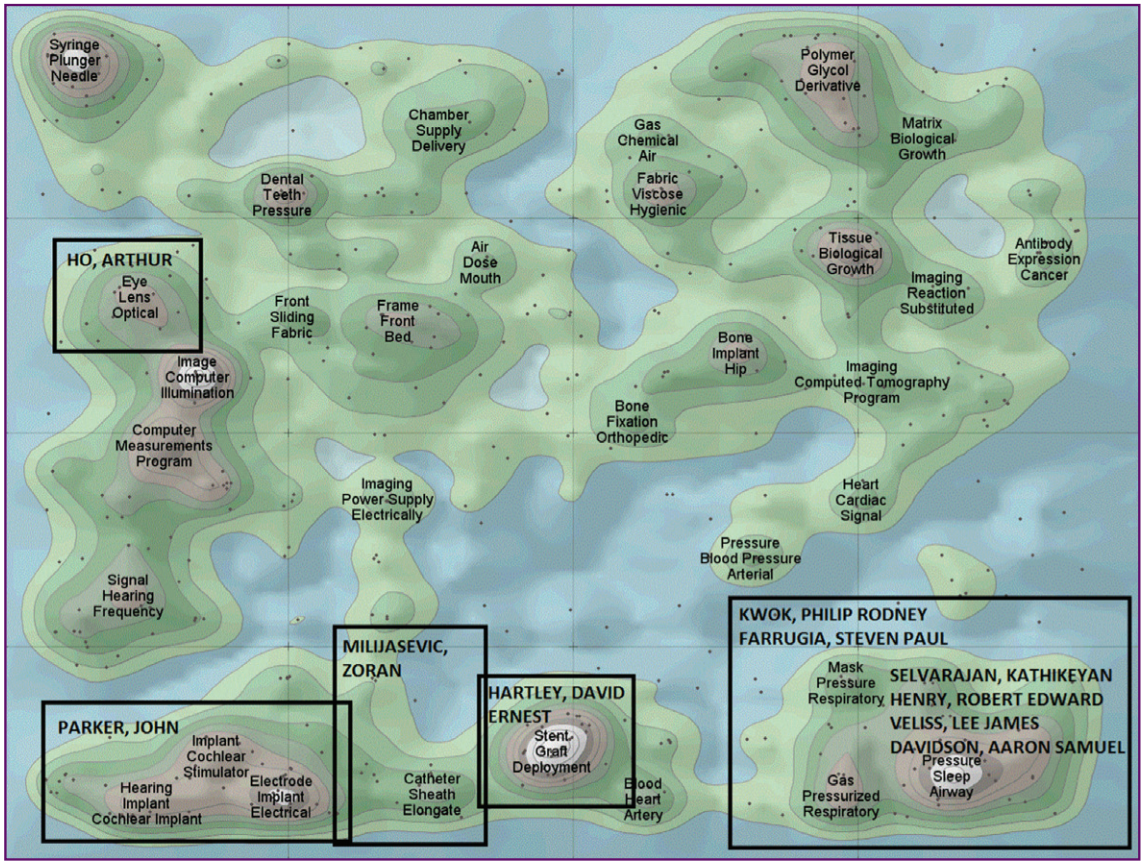


Figure 10: Top inventors (Source: Thomson Innovation)



The top 24 inventors, whose names are associated with 14 to 75 PCT applications, have been mapped against applicants in a co-occurrence matrix in Appendix G. ResMed is associated with 11 of the top 24 inventors found in the medical devices field, whilst Cook and Cochlear are predominantly dominated by one inventor. Most of the inventions filed by Cook are by Hartley; and the Cleveland Clinic Foundation is a US-based applicant that collaborates with Cook on stent-related inventions.

Milijasevic is associated with the catheter and electrode related implantable inventions which span multiple areas of specialisation and are associated with PCT applications filed by: CathRx, Columna, Neopraxis, Spinecell, Acu Rate, Neustent, Murray Vascular, Bivascular Technologies and Cochlear.

Ho has predominantly contributed to the vision related inventions and is an inventor associated with the Vision CRC LTD (PFRO), and other entities such as Institute of Eye Research, Brien Holden Vision Institute, Ocular Sci Inc., Cooper Vision Inc., and Adventus Technology Inc.

Walsh is associated with Global Medisafe Holdings Ltd who specialises in syringe technology.

5.3 Top applicants

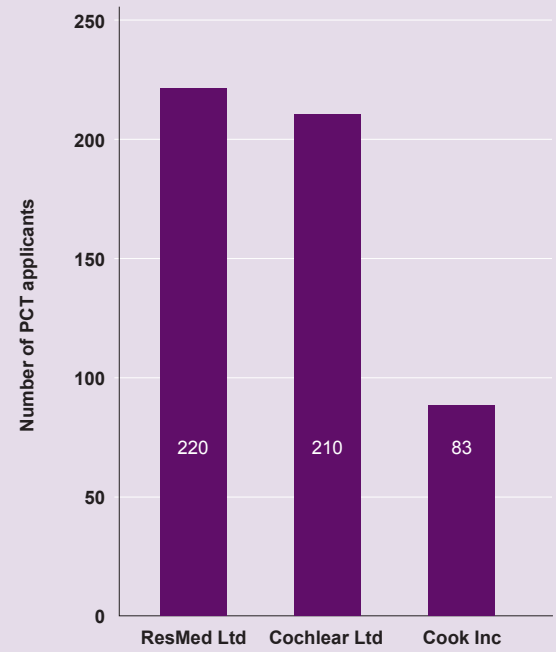
The top three applicants are ResMed, Cochlear and Cook (Figure 11) and they contribute 19 per cent of Australian-originated PCT applications.

The percentage contributions of the top three applicants to the total PCT applications over time are shown in Figure 12, which shows that the top applicants with unique areas of technological specialisation contribute to approximately 11 to 27 per cent of the overall applications. The remaining 73 to 89 per cent of applications is due to the cumulative applications of other entities not classified in this report as a top applicant.

Figure 13 highlights the inventive activity of the top applicants. In 2005, ResMed filed 20 per cent of its PCT portfolio; in 2006, Cook filed 19 per cent of its total portfolio; and in 2008 Cochlear filed 32 per cent of its total PCT portfolio. The large number of applications by Cochlear in 2008 corresponds to the highest percentage of filings by the top three applications in Figure 11. It is also important to note Cook's declining filing activity, with no applications in 2011 and only one application in 2012.

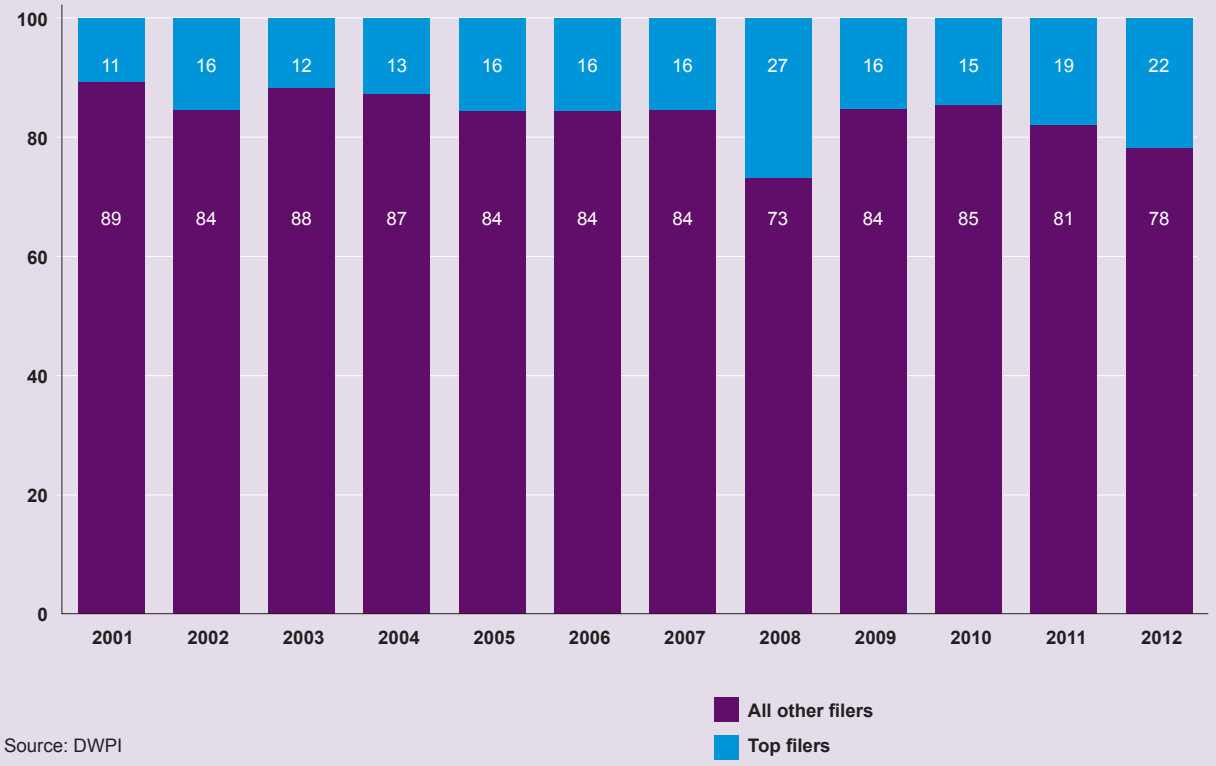
Although further observations on the technological specialisations found in Australia will be made in other sections of this report, a review of the applications that corresponded to the years of high inventive activity for the top applicants is provided below.

Figure 11: Top Applicants



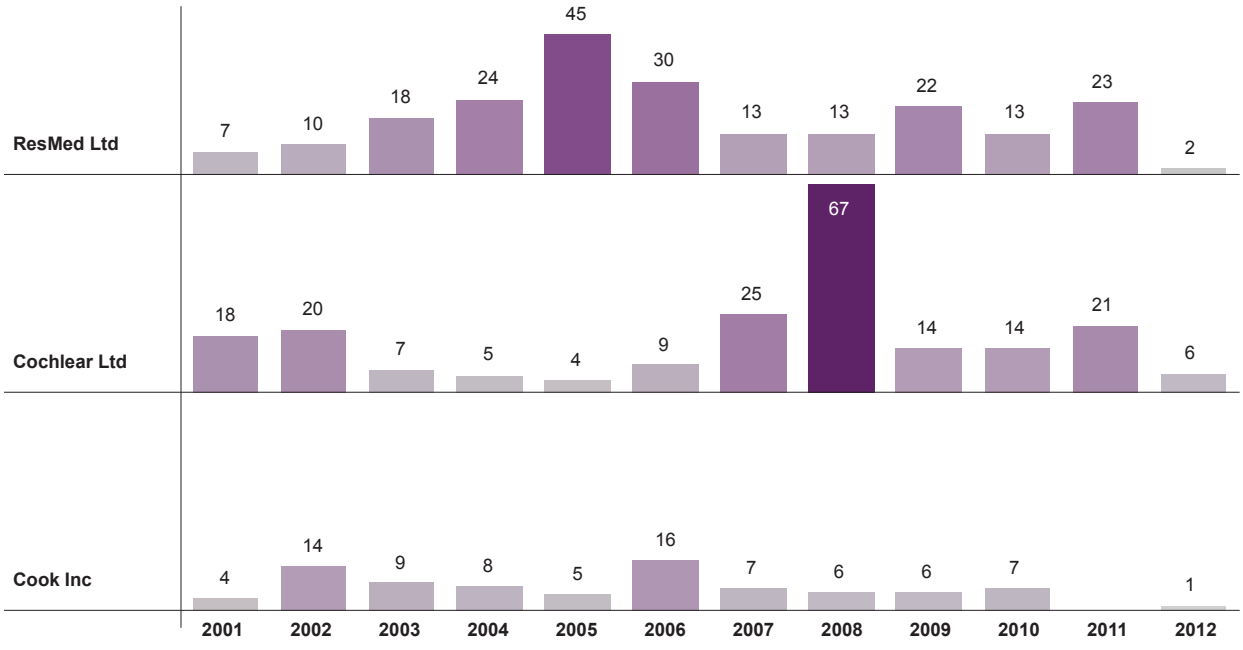
Source: DWPI

Figure 12: Contributions of the top applicants, by priority year (%)



Source: DWPI

Figure 13: Inventive activity of the top applicants over time



Source: DWPI

5.3.1 ResMed

ResMed innovates in the area of respiratory systems used to administer positive pressure to a patient's airway in order to keep it open while the user is sleeping. These systems are primarily targeted to sufferers of sleep disordered breathing known as sleep apnea (see section 6.2.2). The challenges associated with this medical technology include providing comfortable adjustable design fits for the pillows/cushions, prongs and nozzles of the masks; reducing the noise associated with the system while maintaining steady pressure gas flow with minimal leakage; providing gas wash-out vents to prevent build-up of expired air; providing humidification to ensure that the patient's airway does not dry out; and individualised delivery with compensation for particular patient needs and behaviours.

Review of ResMed's activity from PCT applications originating from 2005 shows that the company was working on all the above mentioned issues with a team of diverse inventors. It is also evident from the disclosures of the applications filed that the following commercial products were on the market: Activa®, ResMed's S7 CPAP model, Ultra Mirage® Nasal Mask and Bubble Nasal Mask, so the inventive activity was most likely directed toward improvements on these masks or the development of the next generation of respiratory masks.

5.3.2 Cochlear

A corresponding review of Cochlear's activity originating in 2008 reveals that even though there is one dominant inventor in this area (John Parker), that there is considerable diversity in inventive activity over the course of even one year.

Cochlear predominantly innovates in the area of hearing implants for both conductive and sensorineural hearing loss (see section 6.2.1). Sensorineural hearing loss (SNHL) is where damage to the inner ear or to the nerve pathways from the inner ear to the brain render conventional acoustic hearing aids, which merely amplify received sound, useless. The implants developed by Cochlear deliver electrical stimulation to the nerve cells and in turn to the person's auditory system. Innovations in this area included changes to the electrode assembly, including increasing the number of electrodes and thus the number of channels, that delivers electrical stimulation signals to the cochlea including the shape, miniaturising the components of the implant so that it is now fully implantable, new more effective signal-processing routines for the electronics module that generates the electrical signal representing the acoustic sound, and introduction of piezoelectric transducers that cause sound perception by generating mechanical forces resulting in motion and vibration of a recipient's skull.

5.3.3 Cook

In this report reference to Cook includes the following entities: Cook Incorporated; William A. Cook Australia Pty. Ltd.; William Cook Europe Aps; Cook Medical Technologies LLC; and Cook Urological Inc.

The year of most abundant invention for Cook was 2006, and like Cochlear one inventor dominated the patent landscape — David Hartley. The Cook applications were all in the area of stents for endovascular or endoluminal deployment (see section 6.2.3). The innovations were directed to the methods of introducing stents to various areas of the body that require specialist configurations such as stents with branched vessels and flared portions, and devices associated with the introduction of them into the body including balloon dilators and multi-port stent graft delivery devices with indwelling guide wires.

5.4 Publicly funded research organisations

The Advisory Council on Intellectual Property highlighted the importance of publicly funded research organisation (PFRO) collaboration with industry and note that PFROs have written strategies for collaborating with industry.[15] In the medical devices field this is demonstrated in Figure 8 which illustrates that Research entities are the most collaborative in the field.

Another way of illustrating the PFRO contributions to the medical devices domain is to visualise their PCT applications over time. Appendix H shows that PFROs such as the Bionics Institute, HEARing CRC, Lions Eye Institute, NICTA, NewSouth Innovations and VisionCRC Ltd file steadily over time. Only four of the 24 entities identified as a PFRO are single filers: Australasian CRC Interaction Design Pty Ltd; Ear Science Australia Institute, The Florey Institute, and the Walter and Eliza Hall Institute of Medical Research.

5.5 CSIRO

CSIRO (also considered to be a PFRO) has filed 42 inventions, nine of which have collaborations. The CSIRO collaboration network is shown in Figure 14.[16] The large red circle represents the 33 inventions filed by CSIRO as the sole applicant. Each of the other numbered circles respresents a collaboration with CSIRO, with each colour highlighting a different entitiy.

Figure 14 highlights the following associations with CSIRO: Meat & Livestock Australia Ltd/ Australian Wool Innovation Ltd (one application shared among three applicants), Bionics Ear Institute/Polyactiva Pty Ltd (one application shared among three applicants), University of Melbourne (one application shared between two applicants), Novartis AG (one application shared between two applicants), IND Technology Res Inst Taiwan Roc (one application shared between two applicants), Gore Enterprise Holdings Inc (one application shared between two applicants) and Polynovo Biomaterials Pty Ltd (three applications shared between two applicants). Polynovo is a commercial spin-off from CSIRO research and the shared applications relate to use of biocompatible polymer compositions in biomedical tissue engineering or drug-delivery applications, biodegradable polymers, and new polyurethane compositions suitable for scaffold applications. The shared application between CSIRO and the Bionics Ear Institute and Polyactiva Pty Ltd relates to a new bioerodible polymer useful in sustained bioactive agent delivery.

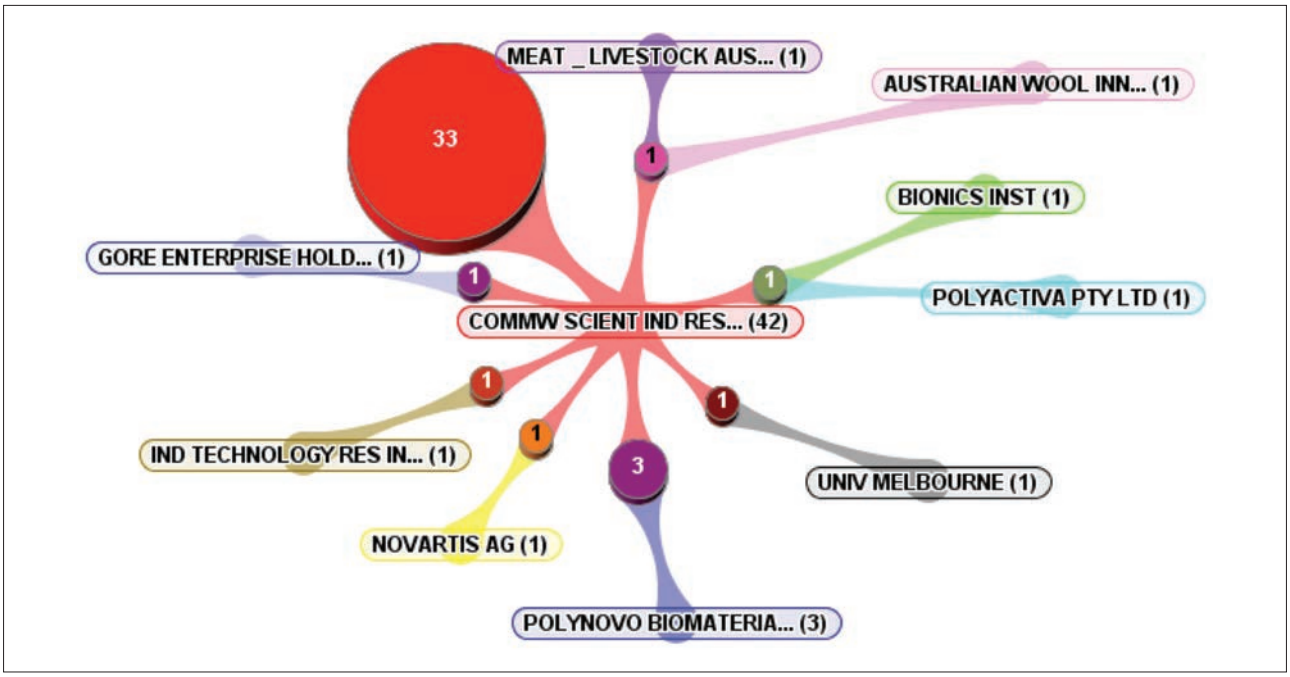
[15] Advisory Council on Intellectual Property 'Collaborations between the Public and Private Sectors: The Role of Intellectual Property' 2012 http://www.acip.gov.au/reviews/all-reviews/collaboration-public-private-sectors

[16] The Aduna Cluster Map contains information visualization technology developed by Aduna Software

Applications which are solely in the name of CSIRO are diverse in technological background, spanning fields such as physics, chemistry, polymers, materials, electronics and imaging. Some notable inventions relate to:

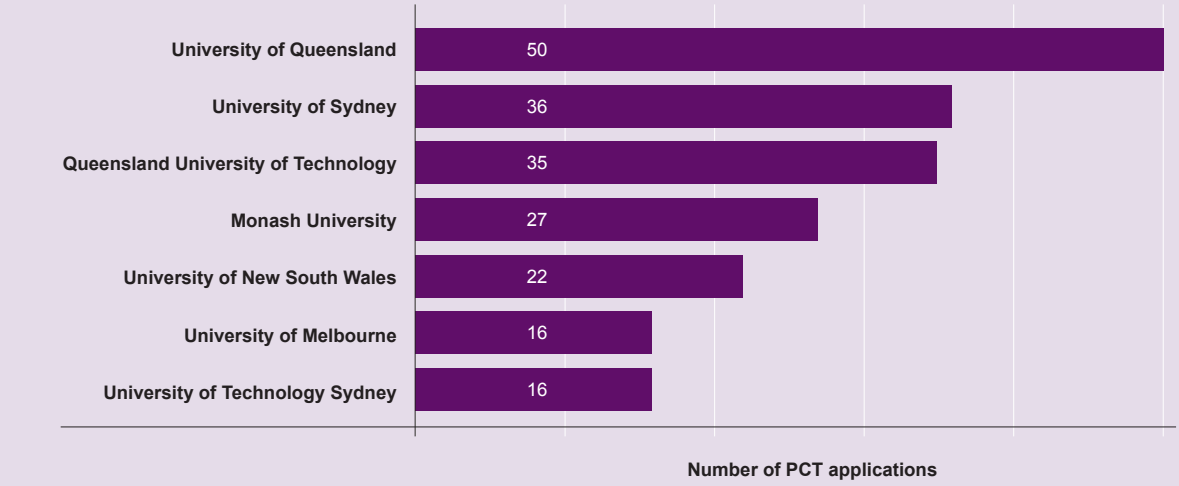
- the delivery of telemedicine;
- polymeric coatings for contact lenses;
- tissue sealants that are photoactivatable and useful in surgical applications;
- a device that may be worn by a person for detecting moisture, for example in a nappy or sanitary napkin;
- esophagus reflux distribution measurement method for diagnosis of dysphagia;
- expandable catheter;
- apparatus for delivering dry aerosols to the respiratory tract;
- a microwave-based blood flow-rate monitoring device;
- use of acoustic energy to determine blood pressure;
- body pressure sensing apparatus based on a light guide incorporating a series of Bragg gratings;
- an image processing technique used to analyse abnormalities in MRI images;
- contrast agents;
- motion accelerometers and other mobility performance measurements;
- methods of acquiring brain data to determine Alzheimer's disease;
- methods and apparatus for defining motion artefacts in an electrocardiogram (ECG);
- method for determining degree of uptake of positron emission tomography (PET) makers in individuals; and
- new metal complexes used in diagnostic imaging.

Figure 14: CSIRO collaborations



5.6 Universities

Figure 15: Top universities



Source: DWPI

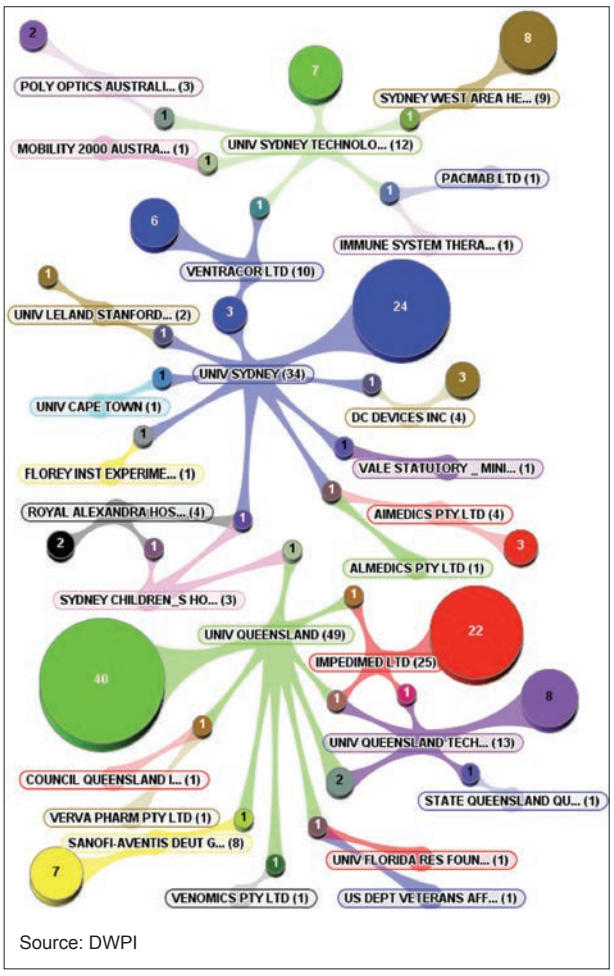
Although universities are technically publicly funded institutions, we have analysed universities and PFROs separately here. The top-filing universities in medical device technology are summarised in Figure 15. Aside from a small cluster of MRI-related inventions attributable to the University of Queensland, activity associated with universities is diverse in technology, like CSIRO.

The patenting activity of Australian Universities can be seen in Appendix I. Early entrants in the medical devices arena include the following universities with PCT applications dating from 2002: the University of Queensland, the University of Sydney, Monash University, the University of Melbourne, ANU and the University of Tasmania. The six top-filing universities file steadily over the study period. The University of Western Sydney is most recent entrant to the medical devices field, with its first PCT application made in 2008. There are four universities with only one PCT application: the University of Adelaide, Murdoch University, the University of Newcastle and the University of Western Sydney.

5.7 University Networks

University collaborations both with Australian entities and foreign applicants are shown in Figures 16 – 22. There are five unique networks with four or more nodes, and five clusters capturing the links between the universities and other entities that have filed within the medical devices area and therefore are represented in the dataset. There are 12 collaborations with organisations identified as a PFRO.

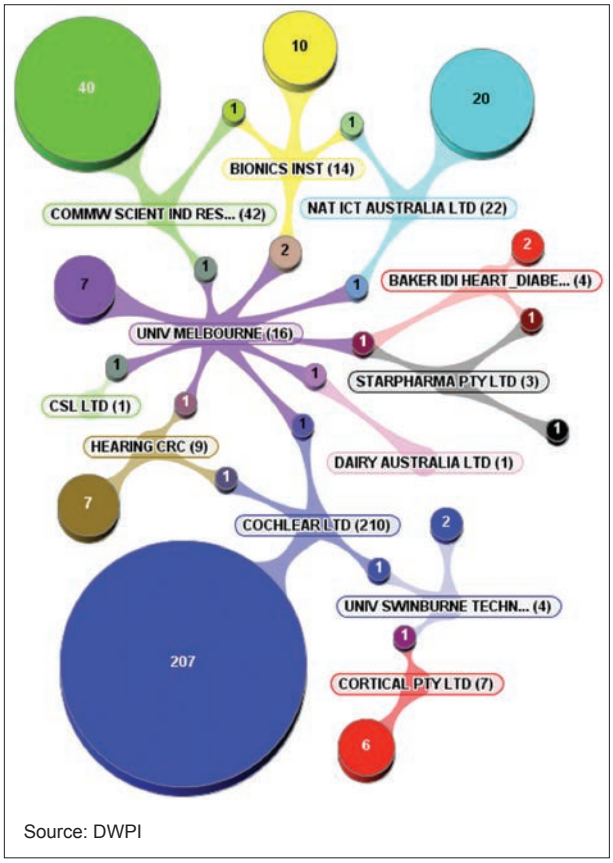
Figure 16: University Network 1



Source: DWPI

Network 1 (Figure 16) is the biggest network and it links the activities of four major filers: Queensland University of Technology (QUT), University of Queensland (UQ), University of Sydney and University of Technology Sydney.

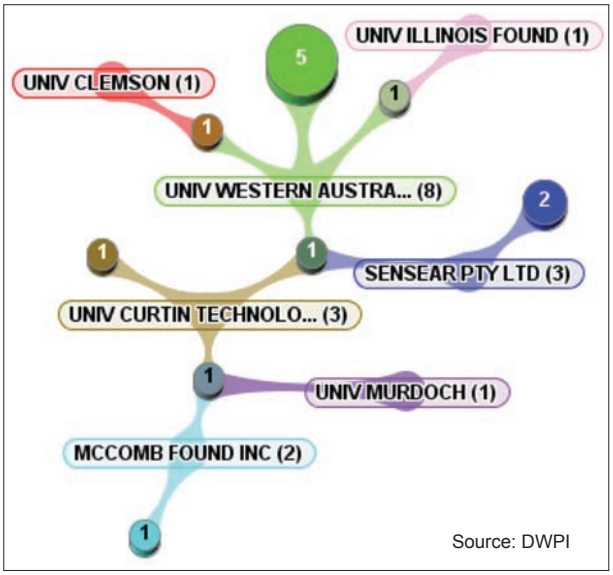
Figure 17: University Network 2



Source: DWPI

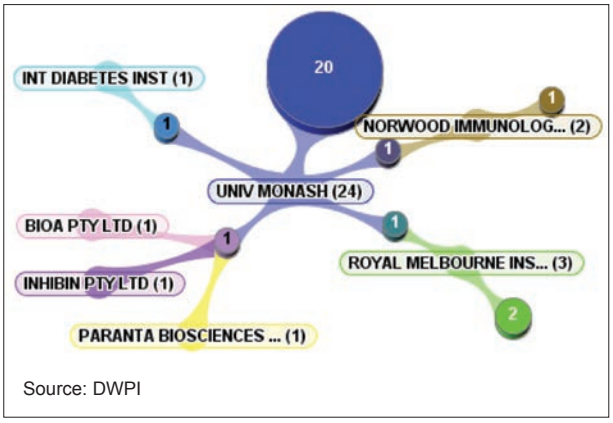
Network 2 (Figure 17), formed around the University of Melbourne, provides a link to Swinburne University of Technology and also identifies that University of Melbourne has collaborated with four PFROs – CSIRO, NICTA, Bionics Institute and the HEARing CRC.

Figure 18: University Network 3



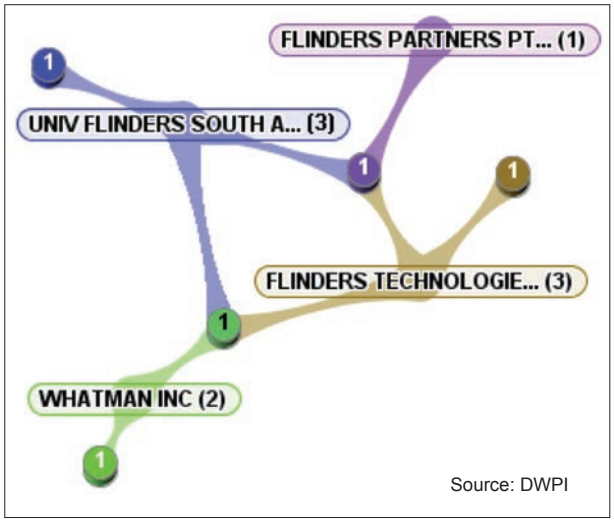
Network 3 (Figure 18) is based in Western Australia and links the University of Western Australia with Curtin University of Technology and the University of Murdoch. Network 3 also includes two international entities, the University of Illinois and University of Clemson.

Figure 19: University Network 4



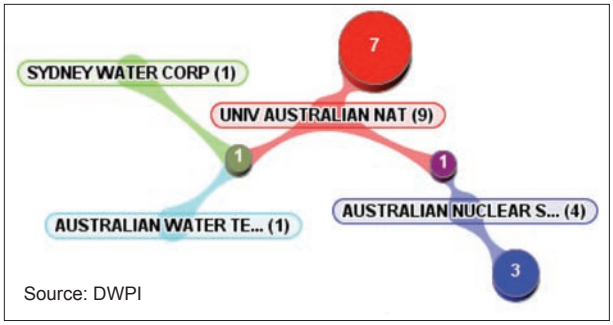
Network 4 (Figure 19) is around the University of Monash with a link to the RMIT.

Figure 20: University Network 5



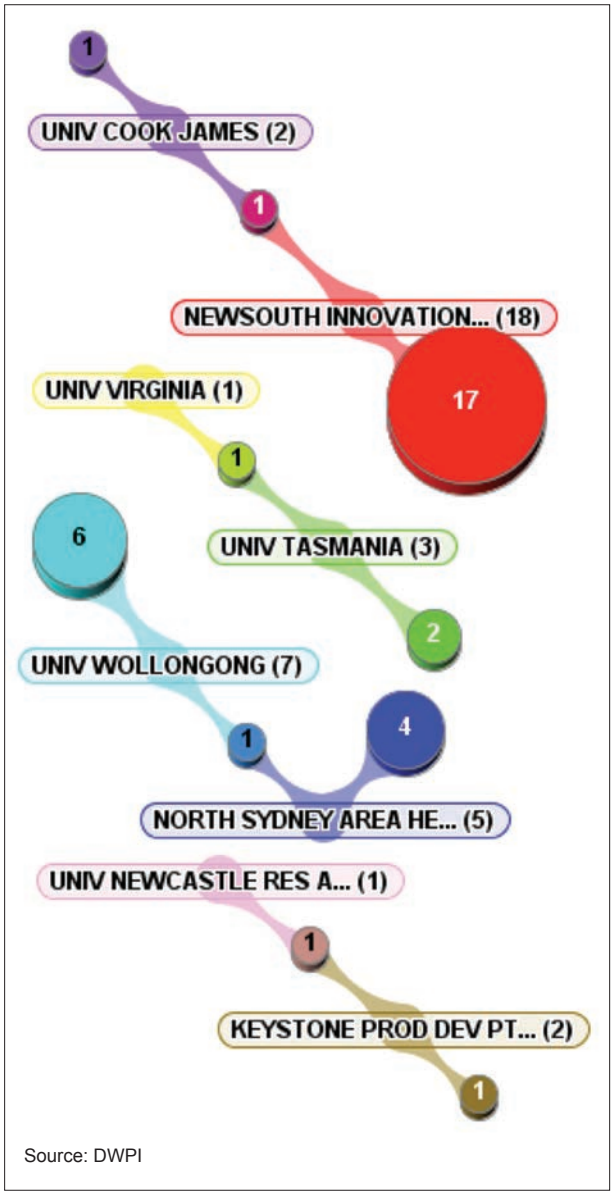
Network 5 (Figure 20) identifies that the only university to be involved in collaborative work in South Australia is Flinders University and its commercialisation arm Flinders Partners.

Figure 21: University Network 6



Network 6 (Figure 21) is around the Australian National University (ANU) with links to ANSTO (PFRO) and Australian Water Technologies, and Sydney Water Corporation.

Figure 22: University Network 7



Source: DWPI

The four remaining clusters (Network 7, Figure 22) define collaborations between pairs of applicants: James Cook University and NewSouth Innovations, the UNSW commercialisation office; University of Wollongong and North Sydney Area Health (PFRO); University of Newcastle and Keystone Prod Dev Pty Ltd; and University of Tasmania and University of Virginia.

Five universities have not collaborated in patents in this field (and are not included on the map): Macquarie University, University of Western Sydney, University of Adelaide, University of South Australia and University of New England.

Using metrics such as number of forward citations (see section 9 for more detail) it is possible to identify valuable patents in the sub-set of PCT applications filed by the universities. The following two applications were identified as valuable patents filed by universities:

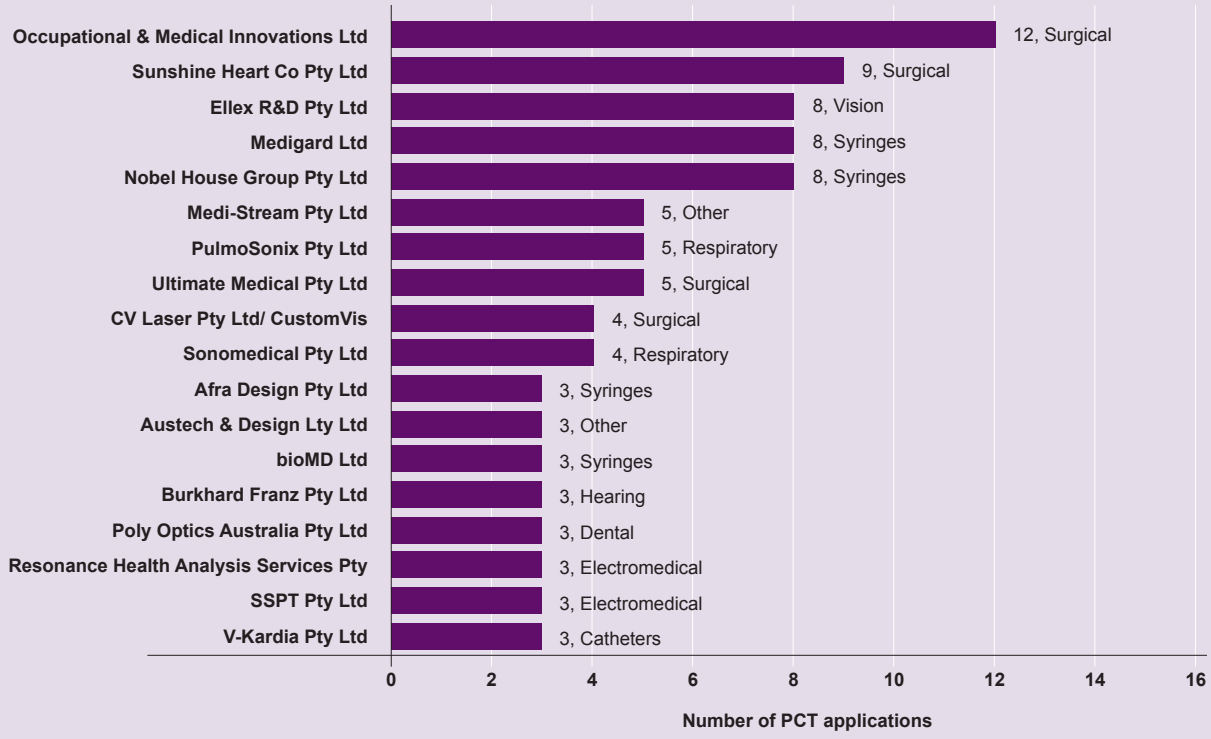
- WO 2003/006091 (University of Western Australia) has the highest number of citing patents out of the university applications with 43 cites. The invention is an infusion apparatus for regulating blood sugar levels of patient, comprising a controller which communicates with component sensor and infusion systems.
- WO 2002/072870 (Flinders Technologies Pty Ltd, Flinders University & Whatman Inc) is discussed in section 9.2 and is directed to an invention titled: 'Solid medium for storage of DNA, esp. blood DNA comprising solid matrix having compound or composition incorporated or absorbed to protect against degradation of DNA'. This PCT application has the highest number of citing patents for its patent family for a university PCT application, with 144 cites. The collaboration with Whatman Inc. (a US-based entity) indicates industry sponsorship of Australian university research resulting in a valuable IP right.

5.8 SMEs

The top-filing SMEs in this technology have been summarised in Figure 23. As is clear in the figure, the major area of innovation for SMEs is in the Surgical field. Vision is also a developing area with two firms indicated here, Ellex R&D Pty Ltd and CV Laser Pty Ltd, which are developing inventions such as a method for monitoring a patient's eye position used during ophthalmic laser ablation surgery. PulmoSonix innovates in the Respiratory area and Poly Optics Australia innovates in the Dental. SSPT innovates in the Electromedical area (see section 6.3.3) with inventions such as a method of assessing effectiveness of audiovisual, visual or audio advertisement involving calculating steady-state visually evoked potential amplitudes from electroencephalogram signals obtained from scalp sites of subjects.

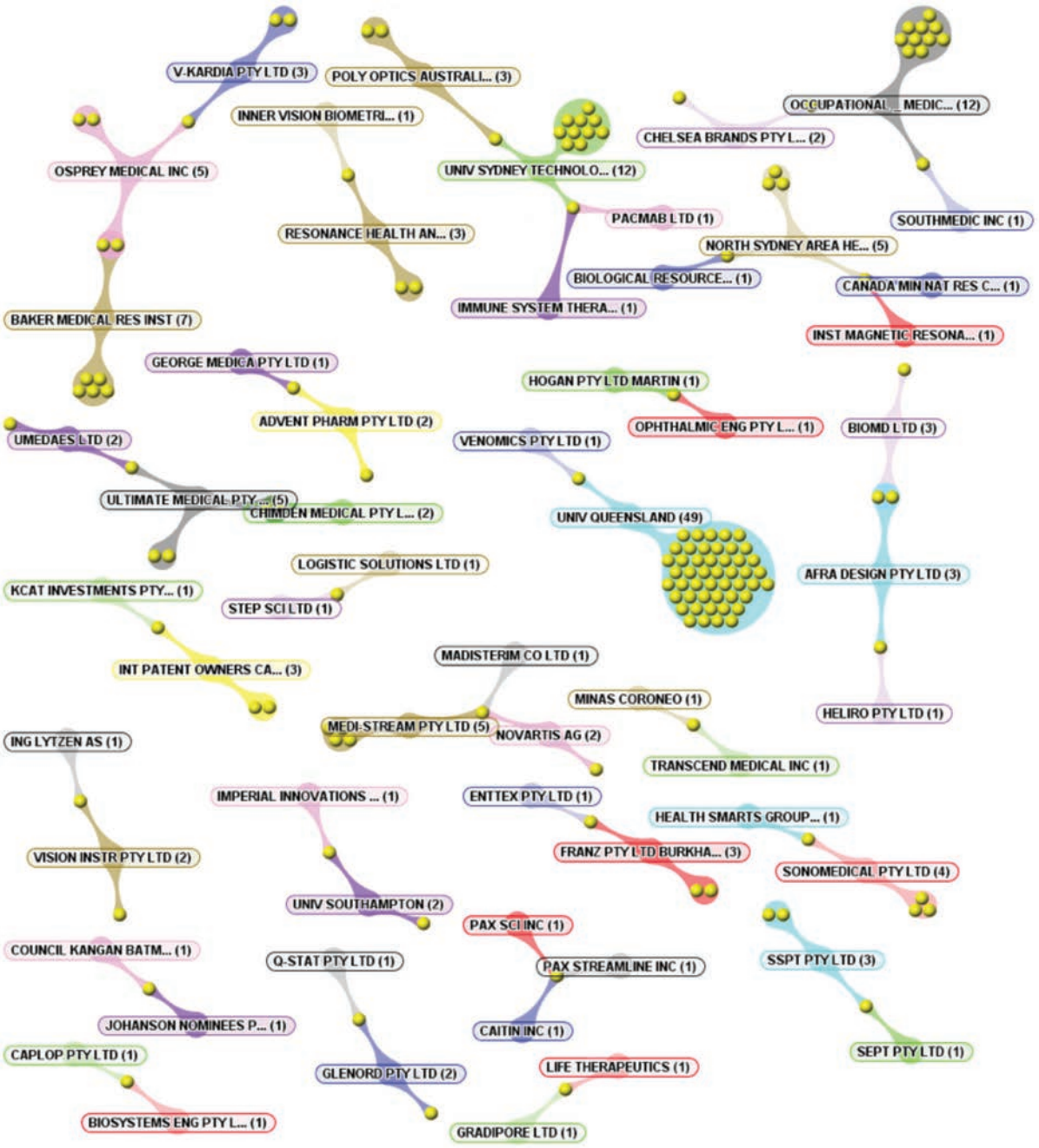
Of the 153 PCT applications identified as being assigned to an SME, 38 were assigned to more than one applicant. All collaborations involving SMEs are shown in Figure 24, with the SMEs highlighted in purple. Appendix J lists the PCT applications that involve SMEs collaborating with each other. Appendix K lists the applications that involve SMEs collaborating with other categories of entities. Of the top SMEs from Figure 23, Medi-Stream has developed a breathing apparatus in collaboration with Novartis; Sonomedical is involved in the Respiratory and Measuring technologies, and has collaborated in methods for determining heart beats; Afra Design Pty Ltd collaborates with bioMD Ltd in the Syringes/ Needles technologies; Burkhard Franz Pty Ltd collaborates with Entex Pty Ltd in the Hearing specialisation (see section 7.1); and Resonance Health Analysis Services Pty collaborates with Inner Vision Biometrics Pty Ltd, another SME, in the Medical Imaging area. V-Kardia Pty Ltd innovates in the Stents area and collaborates with Osprey Medical Inc who specialise in Surgical devices.

Figure 23: Top SMEs



Source: DWPI

Figure 24: Collaborations with SMEs



Source: DWPI

6. Types of medical device inventions originating from Australia

A key aspect of this analytics report is to map the inventions identified using a search of IPC classification marks onto the activities defined by the Australian and New Zealand Standard Industrial Classification (ANZSIC) Classes 2411[17] and 2412[18] which relate to the manufacture of medical devices.

An initial review of the underlying patent data using a combination of ThemeScape and keyword cluster analysis revealed that some activities in the ANZSIC classes under consideration were poorly represented in the patent data (see section 5.2). Therefore, a new technological subject matter grouping was developed which encompassed, where possible, activities available under the ANZSIC classes, IPC groups searched without a correspondence in the ANZSIC, and the aforementioned term clustering which had identified areas of specialisation. The technology specialisations and their origin are listed in Appendix E.

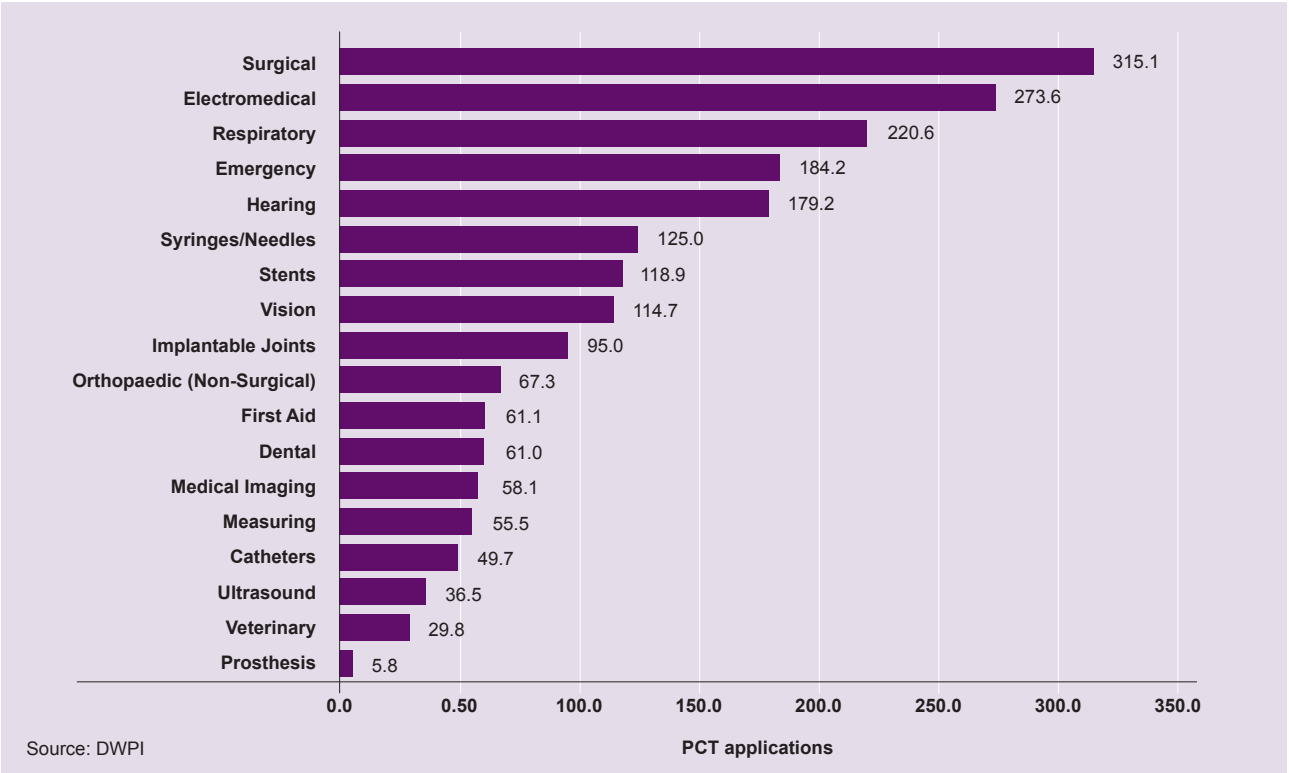
To quantitatively assess a breakdown of the inventions identified in this report against the grouping developed above, the IPCs associated with the inventions and, where needed, keywords found in the application titles were used to allocate the invention to a group or multiple groups as required. As inventions are often classified using multiple IPC marks they can be allocated to more than one group. Therefore to account for this complexity an invention that could belong to more than one group was classified as having a share in each of the groups. Therefore a PCT application that related to both a stent and a surgical method of deployment was given a share of 0.5 for each group. A shortcoming of this type of analysis is that it provides all IPC marks allocated to an application equal value, which may detract from the fact that an invention may predominantly be directed to one area of invention.

The technology sector breakdown is shown in Figure 25. These sectors cover 76 per cent of the PCT applications in the dataset. The remaining 24 per cent are in other technology areas not elsewhere classified, and contain inventions relating to hygiene and sanitation, contraception, medicinal packaging and dispensing, activity monitoring devices to prevent injury, massaging devices, apparatus to assist in healing, means for screening or testing for disease e.g. cancer, and technological inventions that rely on use of computers or the internet.

[17] Class 2411 Photographic, Optical and Ophthalmic Equipment Manufacturing: http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/1D2D8AE15AD5FB1ECA257B9500133C75?opendocument

[18] Class 2412 Medical and Surgical Equipment Manufacturing: http://www.abs.gov.au/AUSSTATS/abs@.nsf/0/D8AA952974A7D82CCA25711F00146F8F?opendocument

Figure 25: Shares of medical device PCT applications per technology specialisation



Source: DWPI

Areas of specialisation such as Syringes, Vision, Surgical, Implants, Catheters, Dental and Veterinary have emerged as such because of the cumulative contribution of many applicants. The technological specialisations that emerged based on applicant participation mirrored those identified against the ANZSIC classes, however, in some areas it was easier to create a new grouping or ecosystem that more appropriately captured applicant's specialisation. The technology specialisations that emerged and the number of applicants in each group are summarised in Table 4. Some of the technology specialisations from Figure 25 have been combined to make the applicant-based technology groupings: Implants includes Implantable Joints and Prostheses; Electromedical/Diagnostics includes Electromedical, Magnetic Imaging and Ultrasound; First Aid has been added to Emergency (Life Saving) to create Emergency, and Orthopaedic has been added to Surgical (see Appendix E).

Table 4: Applicants by technology

Category	Number of applicants
Surgical	199
Implants	88
Electromedical / Diagnostics	86
Emergency	62
Vision	62
Dental	59
Respiratory	59
Syringes	59
Veterinary	36
Hearing	35
Measuring	33
Catheters	17
Stents	14

Source: DWPI

6.1 Ecosystem Development

Applicant filing profiles were used to arrive at an ecosystem mapping of technology specialisations, where applicants were practicing entities. Therefore applications made by Private inventor/ Co-applicants, CSIRO and universities have been excluded from the ecosystem development.

Two distinct ecosystems were readily identifiable Ecosystem 1 considered to encompass established applicants is defined by the three technology areas (or hotspots) where a top-filing entity dominates; and Ecosystem 2 includes hotspots of activity where the cumulative contribution of many applicants provide for the observed specialisation. The areas captured by each ecosystem are:

- Ecosystem 1 — Hearing with top-filing entity Cochlear, Respiratory with top-filing entity ResMed, and Stents with top-filing entity Cook.
- Ecosystem 2 — Surgical, Implants, Electromedical/Diagnostics and Vision, and where multiple entities contribute to the observed specialisation.

Some PCT applications were classified into more than one category due to the nature of their technology and may therefore appear in more than one of the ecosystems below.

Using timeline analysis, current growth in an area can be observed. Signs of continued growth are based on activity occurring in the last three years of the timeline, 2010–2012, which include total filings combined with the number of new applicants entering the field.

The following sections summarise the timeline analysis among the entities that make up technology specialisations.

6.2 Ecosystem 1: Established hotspots

6.2.1 Hearing

The inventions relating to the technology specialisation Hearing include hearing aids, cochlear implants and signal-processing technologies incorporated within unique control components.

Hearing has 24 practicing entities (not including private inventor/co-applicants). Appendix L shows the number of PCT applications filed each year by these applicants, wherein the applicants are ordered by total applications. Two applicants are considered to be early entrants in this field dating to 2002: Cochlear (top applicant) and HEARing CRC (a PFRO). These two applicants together with the Bionics Institute are also considered to be steady filers with PCT applications dating to 2011–2012. Late entrants include Widex As (2010), Australia Hears Pty Ltd (2009), Loud and Clear Safety Pty Ltd (2008) and Neurostimulation Devices & Technology Pty Ltd (2009). Interim filers include Dynamic Hearing Pty Ltd, Neuromonics Pty Ltd and Sensear Pty Ltd. There are eleven single-filing entities.

The combination of PFRO contributions, Cochlear's steady filing activity to 2012 and four late entrants into the field indicate that Hearing is still a growing technology area. The year 2008 has particular relevance with a large spike of applications identified in which probably was a major factor in the corresponding increase in PCT filings across technologies demonstrated in Figure 2.

6.2.2 Respiratory

The inventions in the Respiratory technology specialisation for the most part relate to methods and devices used to deliver breathing assistance to those people who are affected by sleep apnea or asthma.

Respiratory has 34 practicing entities (not including private inventor/co-applicants).

Appendix M shows the number of PCT applications filed each year by said 34 applicants, wherein the applicants are ordered by total applications.

Early entrants in the Respiratory technology specialisation with applications dating from 2001 include Australian Cent Advanced Medical Technology, Infamed Ltd, ResMed and Sonomedical Pty Ltd. ResMed is the only steady and prolific filer in this area but of note is the spike of activity occurring in 2004–2005. Late entrants include Visecor Pty Ltd (2012), Medical Device International Ltd And Ventific Holdings Pty Ltd (2010). Interim filers include: Map Medizin Technologie GMBH, Plastiflex Group, PulmoSonix Pty Ltd and SAIME. There are 21 single-filing entities in Respiratory.

6.2.3 Stents

Stent technologies are directed to both special use stents with bifurcated or branched shapes and methods/devices for their deployment in the body.

There are 10 specialists in this technology area as illustrated in Appendix N. Early entrants into the field include Cook Inc. and Endosystems LLC both having filed PCT applications in 2001. Cook, a top-filing entity, is the only steady and prolific filer in this area. Interim filers include the Cleveland Clinic Foundation and Medical Products Institute Inc. who are both collaborators with Cook (see Figure 28). There are three single-filing entities: Allvascular Pty Ltd, Bivascular Technologies Pty Ltd and Endosystems LLC. The latest entrant in this area is Murray Vascular Pty Ltd but dates to 2008.

Filing activity in Stents is characterised by one dominant player with steady filing, which has decreased over time. Furthermore, the last new entrant entered the field in 2008. This combination of factors indicates that Stents is no longer a growth area.

6.3 Ecosystem 2: Emerging hotspots

Ecosystem 2 comprises emerging hotspots of activity based on the cumulative contribution of many applicants. An emerging technology area (or 'hotspot') is defined as one that demonstrates an increase in the number of PCT filings by applicants in this technology area, in particular one that has continued this trend beyond the peak demonstrated in 2005–2008 (see Figure 2).

6.3.1 Surgical

Figure 25 shows that the majority of the inventions in the medical devices technology relate to surgical advances, according to our technology grouping. Some examples of the type of inventions in this group include bone markers for arthroplasty, bur guides used to cut bone, a calibration device used to locate the axis of tibia in a patient, chambers for automatically sterilising medical equipment, a drill guide assembly for use in orthopaedic surgery, and a guide tool for defining a surgical site.

The technology specialisation Orthopaedic from Figure 25 has been combined with Surgical. Some examples of inventions in the technology group Orthopaedic include bracing and traction devices, stretching devices, leg binding devices, gauges and clamps used to measure and place implants into position, medical rehabilitation apparatus and splints.

The Surgical technology group includes the largest number of applicants in a technology area as its definition is so broad including generally any device, or method relevant to the field of surgery. For the purpose of this timeline analysis Private inventor/Co-applicants were removed from the data set leaving 123 entities.

Early entrants in this field with PCT applications dating from 2001 include: Australian Surgical Design & MFR Pty Ltd, Depuy Int Ltd, Novapharm Research, Occupational and Medical Innovations Ltd, Portland Orthopaedics Ltd, Thoratec Corp, and VentrAssist Pty Ltd (see Appendix O). Steady filers include Depuy Int Ltd, Ultimate Medical Pty Ltd, Cleveland Clinic Foundation and Sunshine Heart Co Pty Ltd. Late entrants are Cpl Holdings Pty Ltd and Globetek 2000 Pty Ltd with their first applications in 2010.

The following entities are noteworthy: Polynovo Biomaterials Pty Ltd, a commercial venture of CSIRO, which invents in the area of polymeric biomaterials used in tissue engineering (see section 5.5); Continence Control Systems International has been set up to commercialise the use of the electrode array invented by Cochlear to stimulate the muscles that form sphincters providing a patient with control of bodily functions. Columna Pty Ltd invents in tissue prosthesis including intervertebral disc implants; SDGI Holdings Inc invents in the area of spinal implant devices and tissue retraction instruments for spinal surgery; and Ventracor/VentrAssist Pty Ltd which invented an implantable blood pump which replaces the left ventricle of the heart. There are 67 single filers in Surgical (not shown in Appendix O) which accounts for half of the applicants.

6.3.2 Implants

Advances within the technology group of Implants can be broadly summarised as due to the use of new materials such as polymers, ceramics, metal and gels. Some exemplary inventions include a biocompatible polymeric material useful for tissue repair and scaffold development

in tissue engineering applications, a nanotube composite for forming electrodes in pacemakers, a new biocompatible ceramic for implants, elastic membranes for encasing blood vessels, intervertebral disc prosthesis, metallics used in joint implants, and gels for the manufacture of soft matter implants used in cosmetic or reconstructive surgery.

The technology specialisation relating to Prosthesis was not very well represented in the patent data and has been combined with Implants. Some exemplary inventions identified related to control systems for prosthesis, a movement facilitation device for moving a finger, and tongue and jaw operable control apparatus for use by a handicapped person.

There is overlap in applicants identified between the implant group and the surgical and hearing groups for obvious reasons – hearing electrodes qualify as implants and surgical inventions are associated with implants. The number of entities, after removing Private Inventor/Co-applicants, in Implants is 59. Early entrants in the field with applications dating from 2001 include Depuy International Ltd, Australian Surgical Design and MFR Pty Ltd, Thoratec Corp, Portland Orthopaedics Ltd, Warsaw Orthopedic Inc, and Heart Assist Technologies Pty Ltd (see Appendix P).

Two late entrants in the field with their first applications in 2010 include: Intigo Giselle Nominees Pty Co Ltd who are developing a prosthetic meniscus and Prosthexis Pty Ltd who are developing a synthetic venous or cardiac valve. Interim filers include Continence Control System International Pty Ltd (previously discussed in section 6.3.1), Dynamic Hearing IP, and Columna Pty Ltd who is developing an envelope which is expanded to fill the void in the spinal column creating an artificial disc. There are a number of steady filers including Depuy International Ltd and Warsaw Orthopedic Inc. There are 22 single-filing entities in Implants (see Appendix P).

6.3.3 Electromedical/Diagnostics

The second most prevalent technology specialisation in the patent data is Electromedical. Many of the inventions in this group relate to implantable electromedical devices such as electrodes assemblies that provide for neurostimulation. The applications in this group often share an IPC mark with the Hearing group.

The applicant technology specialisation Electromedical/Diagnostics also incorporates technology areas Medical imaging and Ultrasound. In Medical Imaging, aside from inventions directed specifically to magnetic resonance imaging (MRI), there are also advances in diagnostic imaging systems using fibre optic bundles such as in contact endoscopic imaging. Tomography using single photon emission and positron emission are captured in this area including new compositions of contrast agents.

Inventions in the group Ultrasound relate to the manufacture of ultrasound devices including signal analysis and imaging, use of contrast agents to measure microvascular capillary flow, and therapeutic applications of ultrasound.

The Electromedical/Diagnostics group also includes within it a large group of applicants. Private Inventor/co-applicants were removed from the data set leaving 72 entities for the time line analysis. Early entrants with applications in 2001 include Compumedics Ltd, Techmin Pty Ltd, Heart Assist Technologies Pty Ltd, and NewSouth Innovations Pty Ltd. Late entrants with applications in 2011-12 include Cilag GMBH International, Manscan Ltd, and Modular Therapeutx LLC (see Appendix Q).

Compumedics, a sleep monitoring company based in Melbourne, (previously highlighted in other sections of this report), is a steady filer with PCT applications dating to 2010. The other dominant steady filers include: ImpediMed Inc. and NewSouth Innovations Pty Ltd. ImpediMed provides bioimpedance devices for a variety of health care monitory uses include monitoring secondary lymphedema, general health assessment including weight management, muscle wasting and drug dosing. The technology underpinning ImpediMed was developed by researchers at the University of Queensland (UQ) and Queensland University of Technology (QUT).

National ICT Australia Ltd (NICTA) began filing in 2008 and had a surge of applications in 2011. Signostics as a specialist in the area of ultrasound imaging is classified as a dominant interim filer with 17 applications from 2005 to 2009. Signostics was established in Adelaide SA in 2005 but has now expanded to the US. Single filers also dominate in this area comprising a total of 43 entities out of the 72 (not pictured in Appendix Q).

6.3.4 Vision

Vision is currently an exciting field in Australia with at least two university groups in Melbourne working on the development of bionic vision devices.[19] The area includes devices such as spectacles, contact lenses, bionic vision devices and intraocular implants as well as surgical methods of treatment. Some examples of inventions from this group include computer based processes for automatically prescribing and dispensing ophthalmic lenses, contact lenses that correct for wavefront aberration, devices used for performing intraocular surgery, retinal rejuvenation laser devices and ophthalmic laser systems for performing eye surgery, and methods of treating presbyopia by refiling the polymeric material in synthetic intraocular lenses.

The timeline for PCT applications of 46 entities (not including private inventor/co-applicants) inventing in Vision illustrates a number of early entrants in the field with applications dating from 2001, including Ellex R&D Pty Ltd, Lions Eye Institute, Novartis AG (in collaboration with CSIRO) and Q-Vis Ltd (see Appendix R). Ellex has continued its research activities and has PCT applications dating to 2010 with later inventions relating to use of lasers to treat age related macular degeneration. Similarly the Lions Eye Institute, a PFRO, has applications to 2009 with its latest invention in virtual eye care service systems. Q-Vis had only one other filing in this area in 2002. Late entrants in this area include Adventus Technology Inc. and Oculeve both with PCT applications in 2011. Steady filers include the Brien Holden Vision Inst and the Vision CRC, whilst interim filers include the Institute of Eye Research, Opto Global Holdings Pty Ltd, Sola International Holdings, and Zeiss Vision Australia Holdings Ltd. The remaining entities are organizations that file in multiple areas, NewSouth Innovations Pty Ltd, Bionics Institute and NICTA. The total number of single-filing entities in this area is 25.

[19] Bionic Vision Australia, Who Will It Help http://bionicvision.org.au/eye/who_will_it_help

6.4 Summary of findings

The information in the timeline analyses can be summarised qualitatively to indicate if a technology area is experiencing growth. The following is a review of the observations made based on the information on late entrants into a field and the most recent filing activity of applicants already present:

Fields growing due to contributions from steady filers and new entrants

- Vision has steady filers filing to 2013 and two late entrants in 2012 with a steady PFRO contribution, indicative of growth.
- Surgical has a large number of entities (130) contributing to the field, with notable applicant Depuy International Ltd having steady applications to 2011. There are two late entrants in 2010 further indicative of continued growth.
- Electromedical/Diagnostics has dominant steady filers as well as three late entrants in 2011–12, indicative of growth.
- Implants has multiple steady filers with activity to 2011 and there are two late entrants (2010), indicative of growth.
- Hearing has multiple steady filers including Cochlear and PFROs with applications in 2011–2012. There are four late entrants into the field, indicative of growth.
- Respiratory has a prolific and recent filer, ResMed, and has seen the entry of three new entities between 2010–2012, all indicative of growth.

Contracting field

The Stents area is not experiencing growth as the overall contribution to filings over the years 2010–2012 by Cook has decreased as compared to previous periods. Moreover, the applications filed by the Cleveland Clinic Foundation and Med Institute Inc. are all co-applications with Cook and therefore do not contribute to the number of filings made in the area from 2010 to 2012. The only ‘new entrant’ in this area is Murray Vascular Pty Ltd with a filing date of 2008.

7. Collaborations for medical device inventions

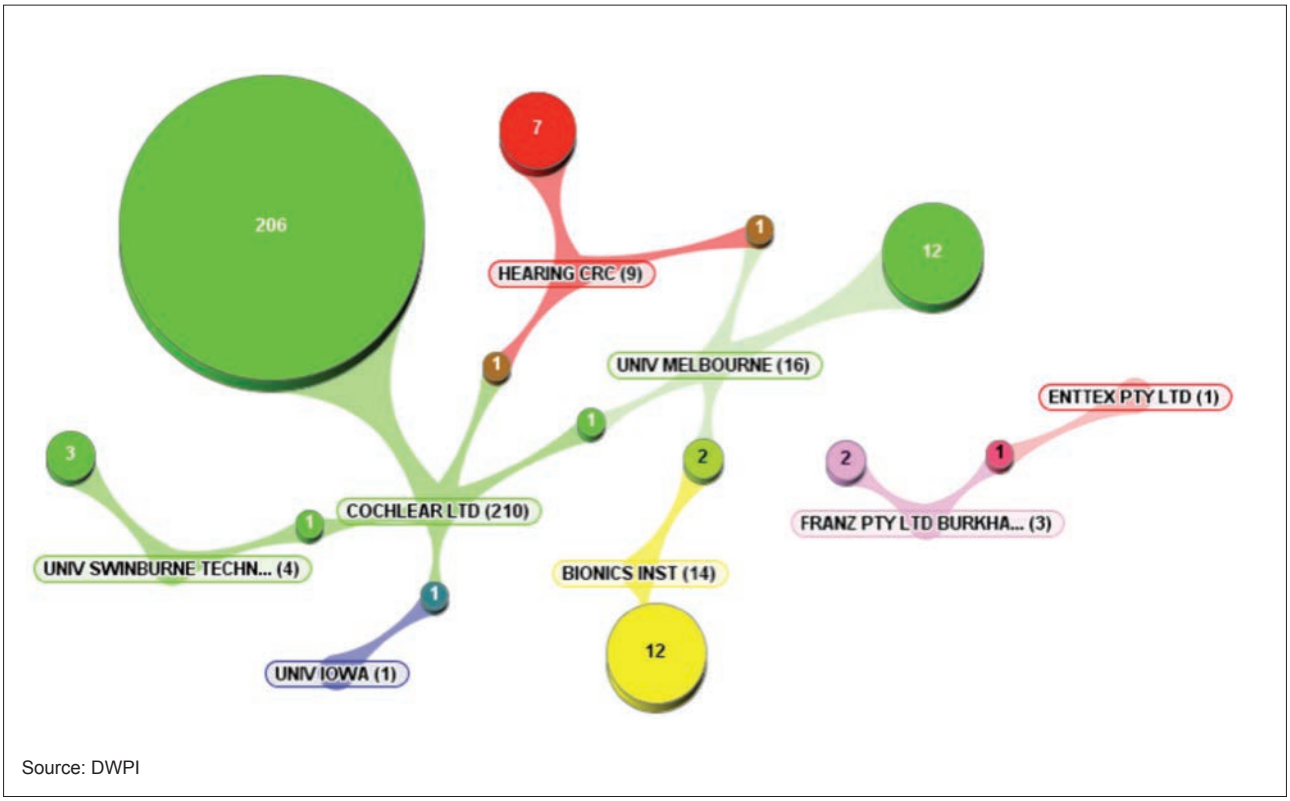
It is also possible to identify whether these applicants are working cooperatively or competitively in these domains by identifying collaborations between applicants associated within a technological area.

The following sections summarise the collaborations among the entities that make up technology specialisations.

7.1 Hearing

Figure 26 maps clusters of collaboration between the universities, PFROs and Cochlear in this field. This figure highlights that Cochlear is the only major player in this field. In this area the University of Melbourne also collaborates with the Bionics Institute and the HEARing CRC. The large green circle represents the 206 inventions filed by Cochlear as the sole applicant.

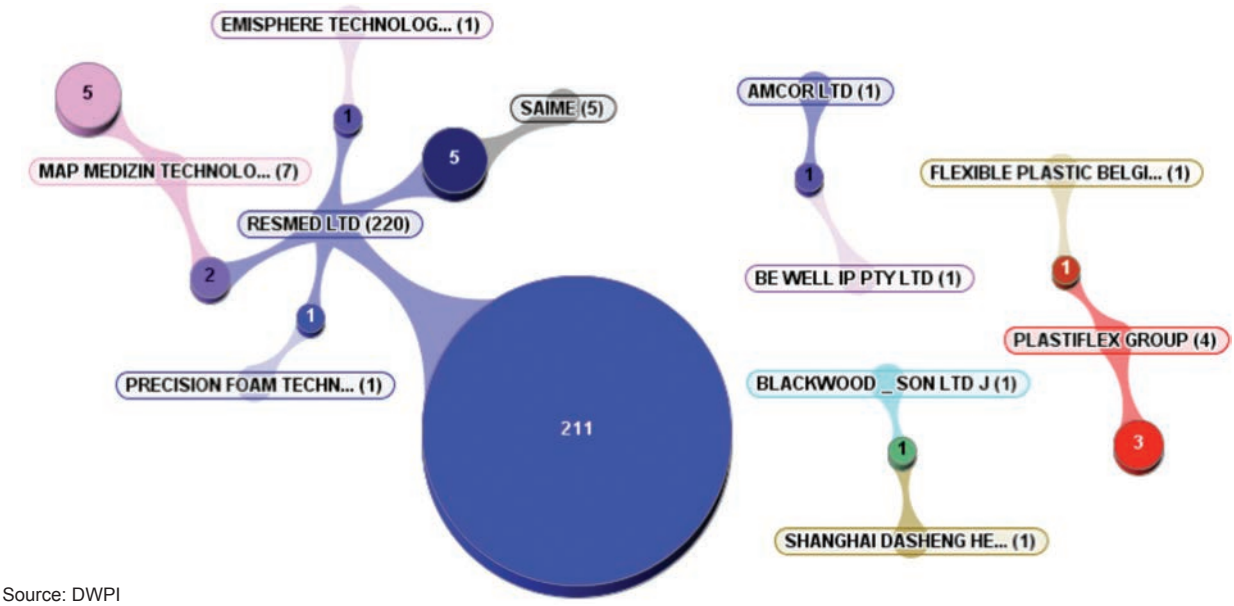
Figure 26: Collaborations in Hearing



Source: DWPI

7.2 Respiratory

Figure 27: Collaborations in Respiratory



Source: DWPI

In the Respiratory area collaborations have resulted in mergers and acquisitions. ResMed is the dominant collaborator (see Figure 27) with joint PCT applications with each of the following entities: Precision Foam Technologies (based in AU, Victoria), Saime SA (based in France), Emisphere Technologies (based in USA), and Map Medizin Technologies (based in Germany). ResMed acquired Saime in 2005[20] and Map Medizin Technologies in 2014.[21] The large blue circle represents the 211 inventions filed by ResMed as the sole applicant.

Three other unique collaborations are evident on the Aduna map between Flexible Plastic Belgium (based in Belgium) and the Plastiflex Group (global company with presence in Asia, Europe and USA); Shanghai Dasheng Health Products Manufacture Co Ltd (based in China) and Blackwood & Son Ltd (based in Australia); and Be Well IP Pty Ltd and Amcor Ltd (both based in Australia).

Therefore out of 34 applicants there are 11 collaborators, seven of whom are single-filing entities.

[20] 'ResMed acquires ventilation company Saime S' http://www.pharmamedtechbi.com/deals/200510111

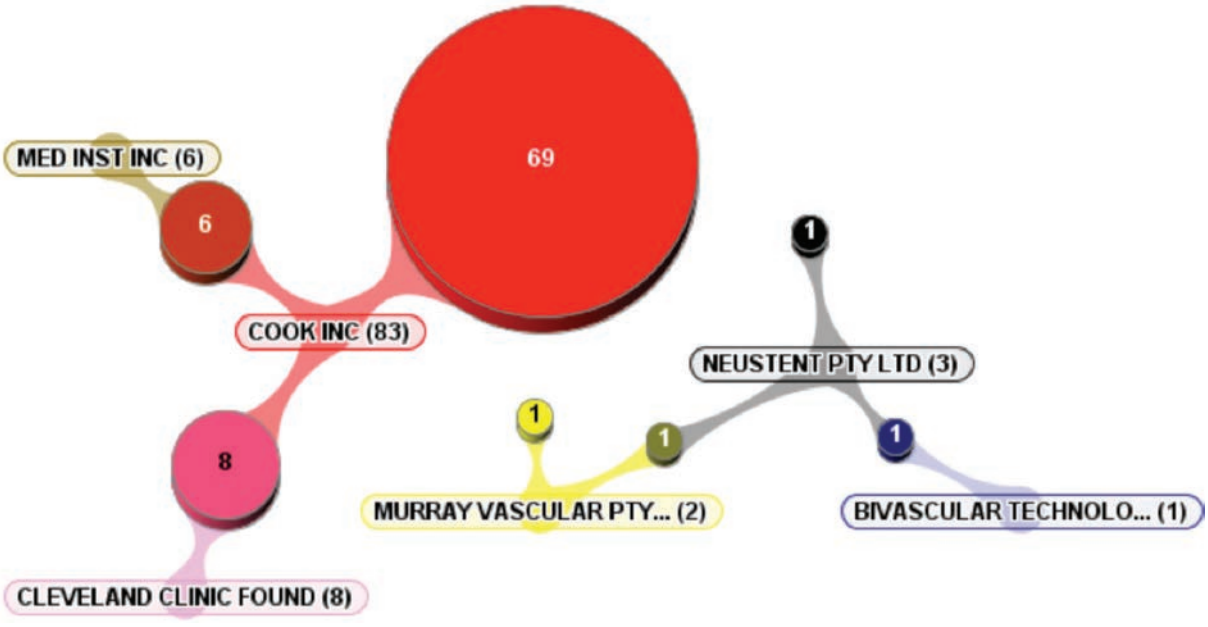
[21] 'ResMed Inc. Acquires MPA Medizin-Techologie GmbH' http://www.privco.com/mergers-acquisitions/resmed-inc-acquires-map-medizin-technologie-gmbh-february-16th-2001

7.3 Stents

In the area of Stents, two networks are observed in the applicant collaborations (see Figure 28): one centred around Cook and the other around the filing activity of Neustent Pty Ltd with Murray Vascular Pty Ltd. Cook collaborates with the Cleveland Clinic Foundation and Medical Products Institute Inc. Medical Products Institute Inc was first established as a resource for the Cook Group of companies to identify and develop new medical product concepts and is based in the United States. The large red circle represents the 69 inventions filed by Cook as the sole applicant.

Therefore out of 10 applicants in this area there are six collaborators, only one of which is a single-filing entity (Bivascular Technologies Pty Ltd).

Figure 28: Collaborations in Stents

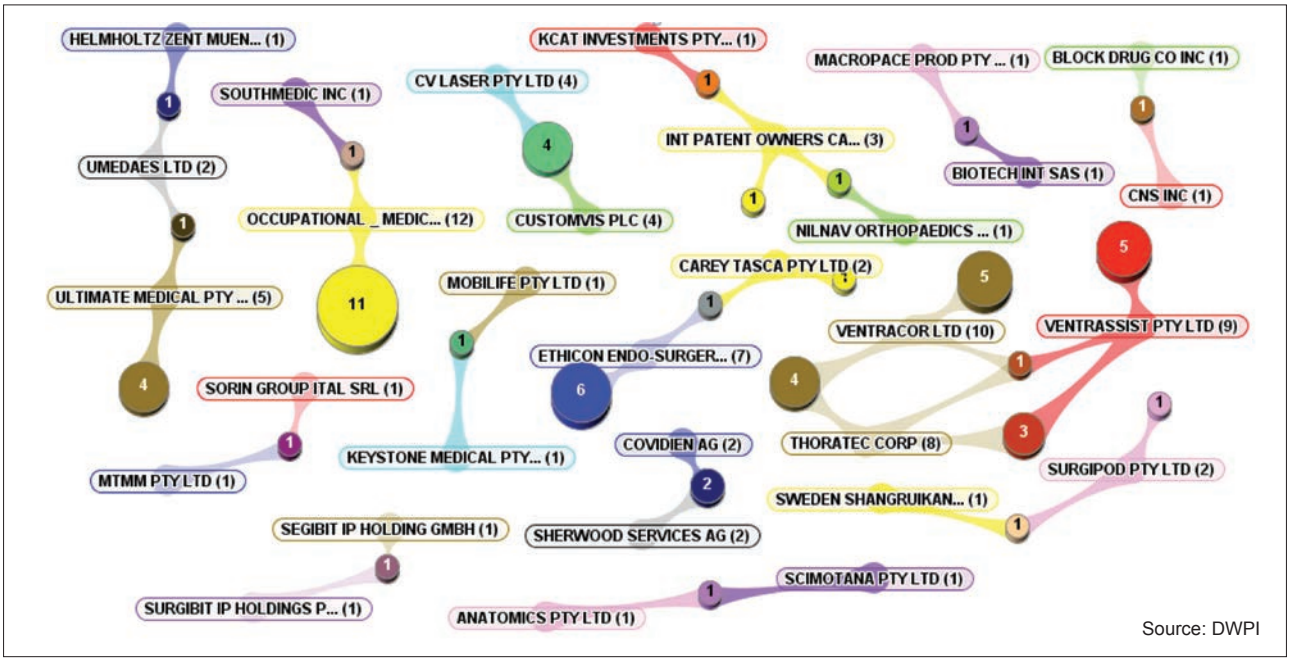


Source: DWPI

7.4 Surgical

There are 29 collaborators in the Surgical area (see Figure 29). Fifteen of these collaborators are single filers (out of a total of 74 single filers in this specialisation) and of these, 10 single filers have collaborated together totalling five sets of single-filer collaborations. The large yellow circle represents the 11 inventions filed by Occupational and Medical Innovations Ltd as the sole applicant.

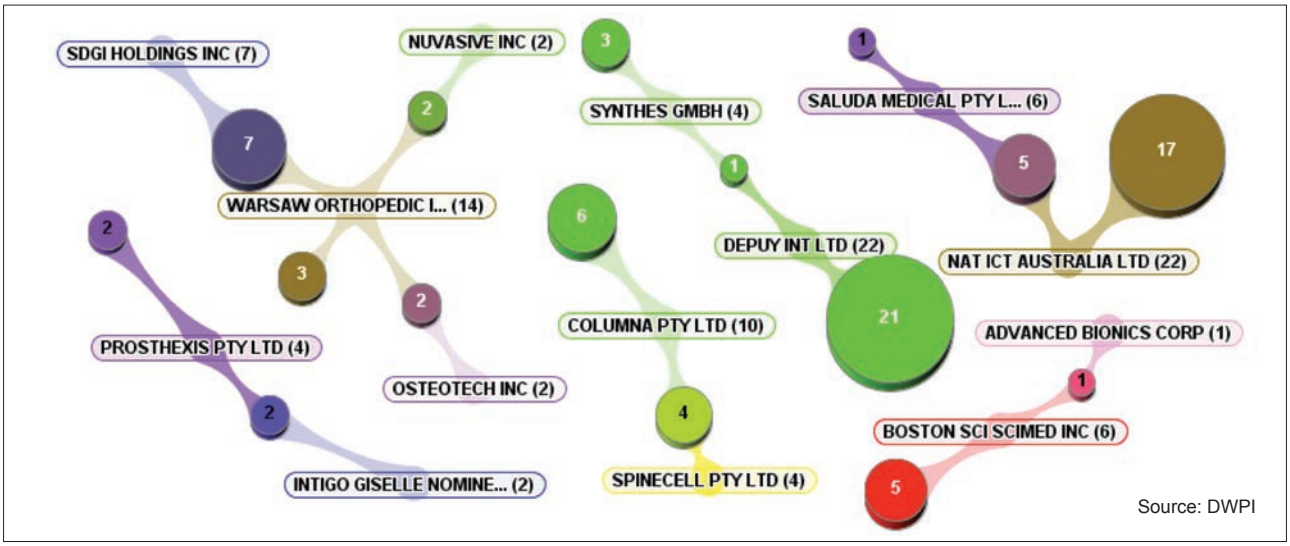
Figure 29: Collaborations in Surgical



7.5 Implants

The practicing applicants in Implants were analysed for collaborative activity and fourteen collaborators were found (see Figure 30). Although there were 20 single filers in Implants, only one single-filing entity was also a collaborator (Advanced Bionics Corp.). This finding would tend to indicate that collaborative behaviour of single-filing entities may be influenced by the specific technology area. The large green circle represents the 21 inventions filed by Depuy International Ltd as the sole applicant.

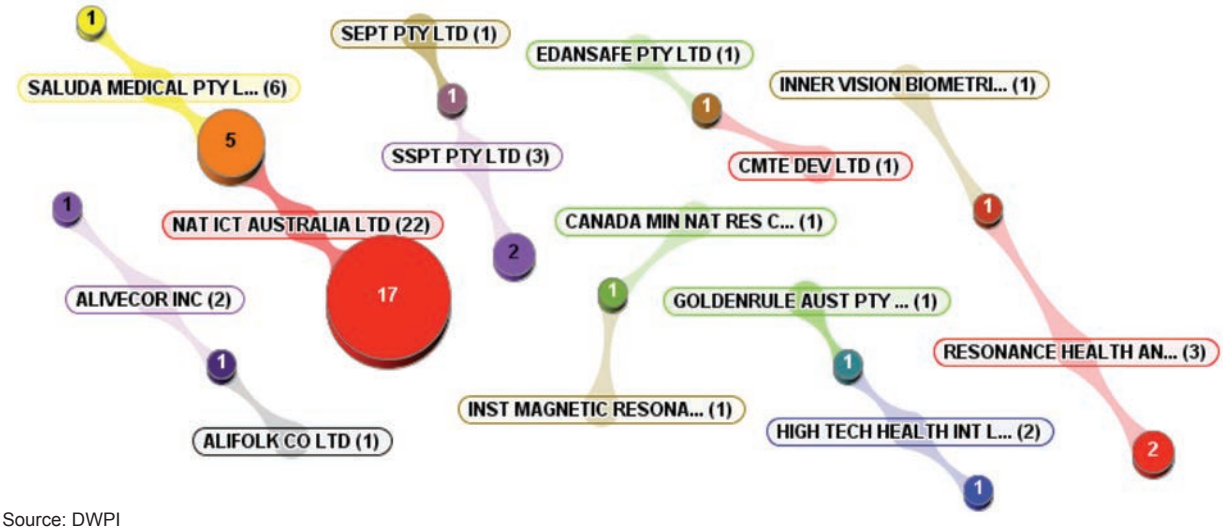
Figure 30: Collaborations in Implants



7.6 Electromedical/Diagnostics

There are fourteen collaborators in the Electromedical/Diagnostics area based on analysis of 72 practicing entities (Figure 31). Eight of these collaborators are single-filing entities. The large red circle represents the 17 inventions filed by NICTA as the sole applicant, or as a collaborator in another field of technology.

Figure 31: Collaborations in Electromedical/Diagnostics

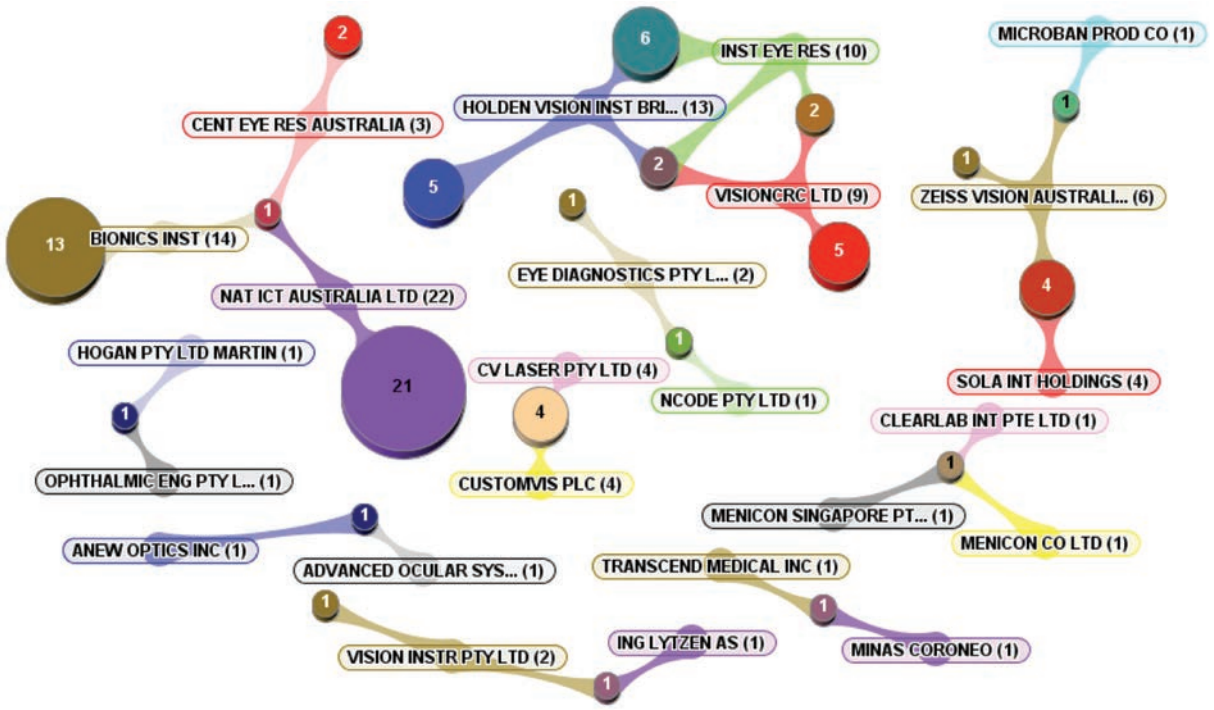


Source: DWPI

7.7 Vision

Twenty-six applicants have collaborated and 14 of these collaborators are single-filing entities (see Figure 32). Four collaborations are solely between single-filing entities. Since 26 out of 49 applicants of the applicants have collaborated in Vision, including half of the single-filing entities, and the involvement of PFROs in the collaboration networks, the Vision technology specialisation is considered to be a very collaborative field. The large purple circle represents the 21 inventions filed by NICTA as the sole applicant, or as a collaborator in another field of technology.

Figure 32: Collaborations in Vision



Source: DWPI

8. Case studies: The use of advanced manufacturing in medical devices

Advanced manufacturing is considered to be any manufacturing technique involving a new material, an automated process or an emerging technique.

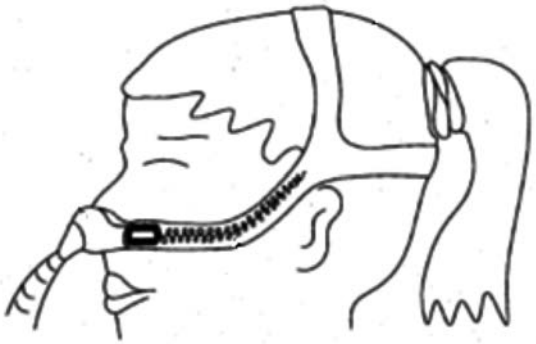
WO 2013/026091 'Manufactured to shape headgear and masks' ResMed Limited

The use of additive manufacturing is prolific in the United States, particularly the dental area, while the same is not seen in Australia. One Australian-originated example of advanced manufacturing techniques is 3D printing, specifically additive manufacturing as 3D Printing, WO 2013/026091 by ResMed.

This document discloses the use of 3D printing to produce customised headgear, a component of a respiratory mask which is used to support the nasal interface while applying positive pressure to the wearer. Traditional headgear is comprised of a rear portion which wraps around the base of the skull and attached straps which connect to the interface. Ideally headgear is manufactured in a unitary piece as seams are uncomfortable for the wearer. Comfort and fit are paramount as the mask must be worn while sleeping. It is also be lightweight and breathable. An example of the headgear is shown in Figure 33. Individual connected links are printed forming a textile which can then be used to form various headgear components. Figure 34 demonstrates the individual links and the use of a printed support (reference numeral 2902 in the figure) with which the printed textile is then integrated.

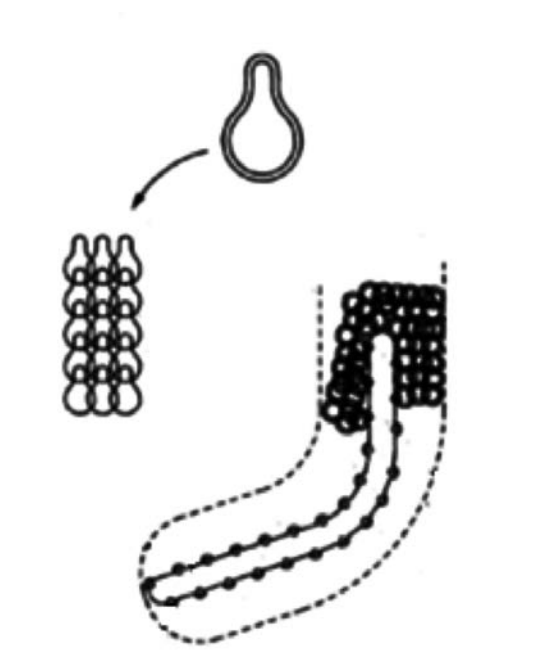
The headgear can be customised for each individual by first capturing data pertaining to the dimensions of the individual's head, such as a photo or 3D scan, specifically the circumference of the patient's crown, the length of the back of the skull to the crown and the position of the patient's facial features. Visual software is then used to generate a model of the head which is then fed into the 3D printing machine.

Figure 33: ResMed mask example



Source: WO 2013/026091

Figure 34: 3D printed links



Source: WO 2013/026091

The inherent nature of this manufacturing technique demonstrates its advantages. By printing the various shapes (instead of cutting out from stock), the amount of material wastage is minimised. In addition, using mapping techniques to capture patient information allows for a conceptually perfect fit.

WO 2012/174596 'Implantable device with plasma polymer surface' The University of Sydney

Another example of advanced manufacturing is active plasma polymer coating for medical devices by University of Sydney. This involves the use of a plasma spray to achieve an active hydrophilic plasma coating capable of bonding to biological molecules on various implantable devices (WO 2012/174596). It makes the metallic components biocompatible and it allows the device to interact with the biological molecules in the body. Artificial joints for instance require safe integration into the bone and such a coating would be useful for this purpose.

This document discloses the use of a co-deposition technique to produce a hydrophilic plasma polymer coating for an expandable medical device, such as a stent or component within a joint replacement. This document is considered an excellent example of advanced manufacturing as it both utilises an advanced material activated to allow the binding of biological molecules, such as proteins to its surface and involves the use of plasma spray to produce the polymer. The structure of the plasma polymer is of particular importance as creating a columnar microstructure overcame previous problems with delamination of the active coating once the device was expanded, as the 'micro columns' absorbed any mechanical stresses generated. In addition, the co-deposition under ionic conditions produces a graded structure of metal-mixed-plasma polymer, such that the coating is integral with the device itself.

The primary example disclosed is that of a stent which would normally encounter problems with coatings delaminating once expanded within the vessel offsetting any advantages of having the coating in the first place. Another possible application is on components within artificial joints to encourage osteointegration.

The plasma polymer coating is activated either during deposition or after the graded structure has been created, allowing it to bind to various biological molecules. Unlike previous techniques of forming a coating this can be applied to any number of molecules and does not require the use of a specific linking molecule. These devices also have a good shelf life because the coating can be reactivated by annealing, for example, if it degrades.

9. Patent impact

9.1 Citation benchmarking

A metric used to identify the overall technological impact of an invention is number of forward citations at a given time. This metric counts the number of times an application has been cited and is time dependent in that the longer a patent is available in the public domain, the higher the likelihood that it may be cited.

Research has shown that the number of citations a patent receives is positively related to its economic value.[22] For this reason, analysis of forward citations is frequently used for the purposes of patent valuation.

The number of citations a given patent receives (forward citations) mirrors the technological importance of the patent for the development of subsequent technologies, and also reflects, to a certain extent, the economic value of inventions. Forward citation counts presented in this benchmarking section are based on EPO patents citations. Forward citations are counted over a period of five years after the publication date. Publication typically occurs 18 months after the filing date of the patent. The windows for observation used should allow capturing the different citation patterns of the technology fields considered. However, the 5 years citation lag decreases the timeliness of the indicator: only patents published up to the mid-2000s can thus be considered.[23]

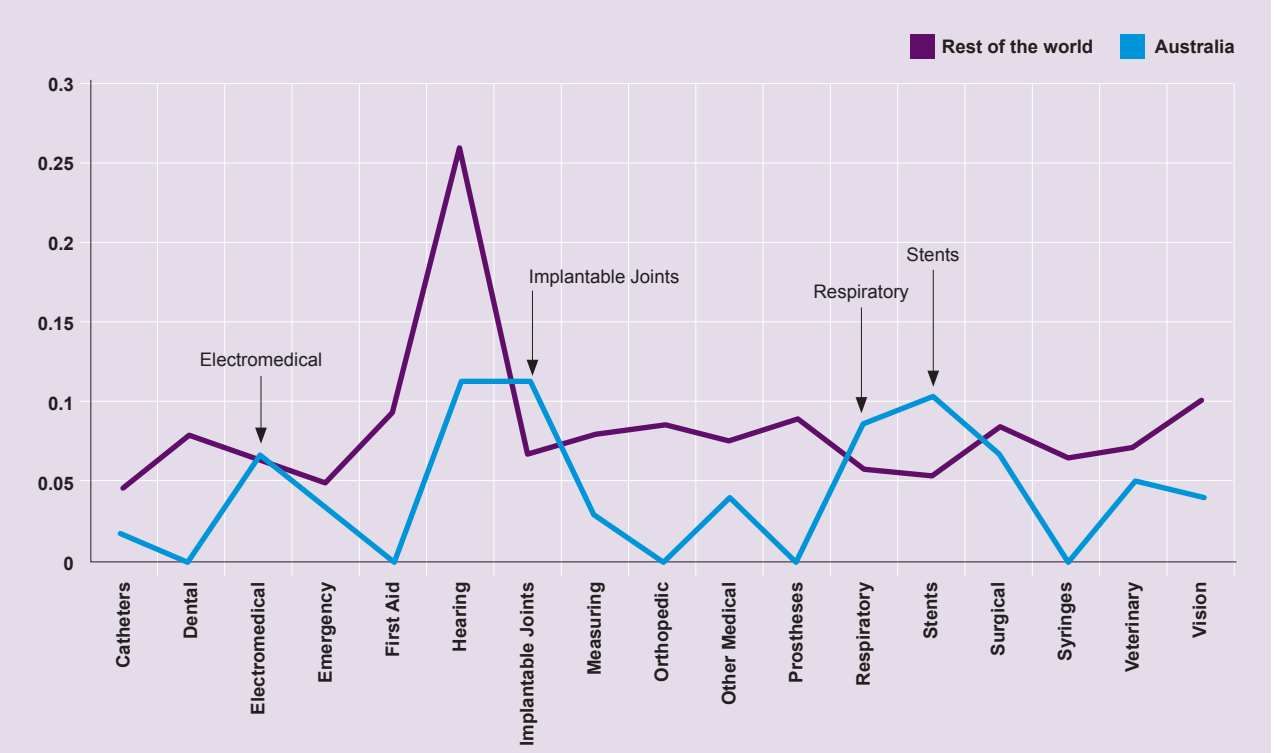
Figure 40 depicts the average number of forward citations five years since publication per PCT application of the PCT applications originating in Australia compared to those originating from the rest of the world. Australia's average number of forward citations is higher than the rest of the world in four technology specialisations: Electromedical/ Diagnostics, Implantable Joints, Respiratory and Stents.

In the Electromedical/Diagnostics specialisation, two Australian originating applications have four or more forward citations five years after publication compared to 13 applications from the rest of the world. In the first of these two applications is WO 2004/017848 (Sheiman Ultrasonic Research Foundation Pty Ltd), the inventor (V. L. Sheiman) is the applicant. The application is in regard to a nebulizing and drug delivery device and it falls within the Electromedical specialisation because of its use of ionised fluids. The second patent, WO 2003/098970 (Hearworks Pty Ltd) also falls in the Hearing specialisation. It discloses an auditory prosthesis which allows the user to adjust a setting which causes the output signal to adjust to the acoustic environment.

[22] Harhoff D., Scherer F. M. and Vopel K. (2002), Citations, Family Size, Opposition and the Value of Patent Rights, Research Policy 32(8), 1343 – 63; see also Trajtenberg M. (1990), A Penny for Your Quotes: Patent Citations and the Value of Innovations, The RAND Journal of Economics 21(7), 172 – 187; and Jaffe A., Trajtenbert M., and Fogarty M., The Meaning of Patent Citations: Report on the NBER/Case Western Reserve Survey of Patentees, NBER April 2000.

[23] Squicciarini, M., H. Dernis and C. Criscuolo (2013), 'Measuring Patent Quality: Indicators of Technological and Economic Value', OECD Science, Technology and Industry Working Papers, 2013/03, OECD Publishing. http://dx.doi.org/10.1787/5k4522wkw1r8-en

Figure 35: Average forward citations five years since publication, by technology



Source: OECD, REGPAT database, January 2014; OECD, Patent Quality Indicator Database, January 2014

In the Implantable Joints and Stents technology groups, one Australian-originating patent has four or more forward citations five years after publication compared to five and four applications, respectively, from the rest of the world. The applicant for this patent, WO 2004/069106 (Synthes GMBH), is based in Switzerland, but one of the three inventors is from Australia. The invention discloses an intervertebral implant which is secured between adjacent vertebrae using longitudinal fixation elements. This patent also falls within the surgical specialisation.

In the Respiratory specialisation, one Australian-originating patent has four or more forward citations five years after publication compared to 5 applications from the rest of the world. This application, WO 2006/074513 (ResMed) relates to a cushion for a patient interface that delivers breathable gas to a patient.

9.2 Top-cited patents

Forward citation counts can be measured using both the originating application as the subject patent, such as the PCT applications identified in this search (as considered in section 9.1), or alternatively the counts can be based on the sum total of forward citations for all the Derwent family members for a given invention (Derwent here referencing the patent database used), referred to as the Derwent Patent Citation Index (DPCI). As the DPCI inherently includes information about national phase entry applications, this metric will be reported on separately to identify valuable inventions.

Using total count of forward citations based on the PCT applications identified in this search, the top six PCT applications (those cited over 100 times) are discussed below.

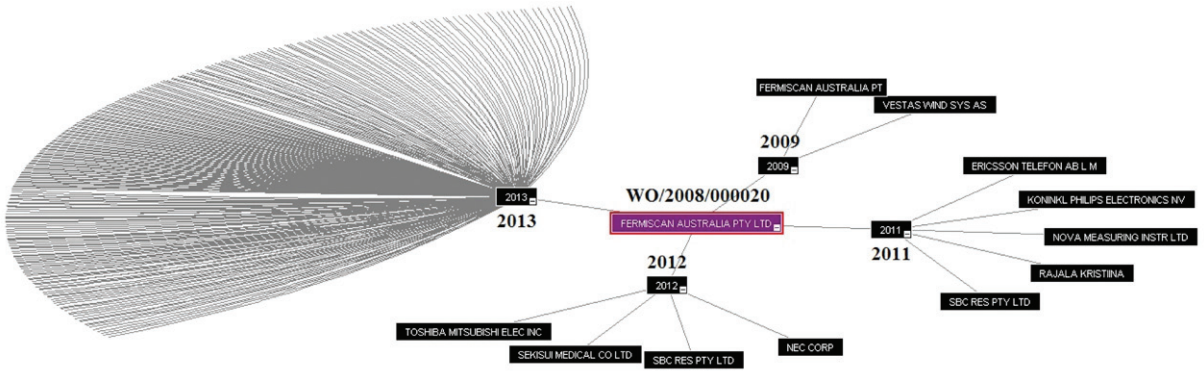
Appendix S identifies the application numbers, number of citing patent counts, the assignee/applicant(s) technology specialisation and the title of the inventions.

The PCT application with the highest forward citation count is WO 2008/000020 (Fermiscan Pty Ltd) with 260 citations. The technology is based on the discovery by Australian scientists that women who have breast cancer have an associated change in the molecular structure of their hair.

The test uses synchrotron-generated X-ray diffraction to identify the alteration of the molecular structure of hair which is associated with the presence of breast cancer. This altered molecular structure gives rise to an altered alpha-keratin diffraction pattern. Pre-clinical studies by the original scientist indicated that the change may be detected early in tumour development.

The Fermiscan application was made public in 2008. In 2009, 2011 and 2012 the Fermiscan application was cited two, five and four times against similar inventions (see Figure 36). In 2013 there was a surge of applications relevant to this technology against which the Fermiscan application was cited. This type of representation with an initial time lag followed by a surge of related applications can be seen to indicate that the Fermiscan invention is ground breaking in this field and there are may be many advances in this area in the future.

Figure 36: Citation tree for WO 2008/000020 (Fermiscan)

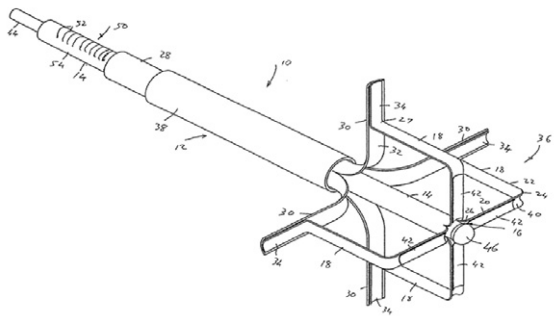


Source: Thomson Innovation

The second most cited PCT application is WO 2010/000020, cited 114 times and published in 2010. The applicant is CathRx Pty Ltd and the invention relates to a catheter sheath with special collapsible assembly that can be inserted into the heart of a patient and then expanded to allow for ablation therapy (refer to illustration of the invention in Figure 37).

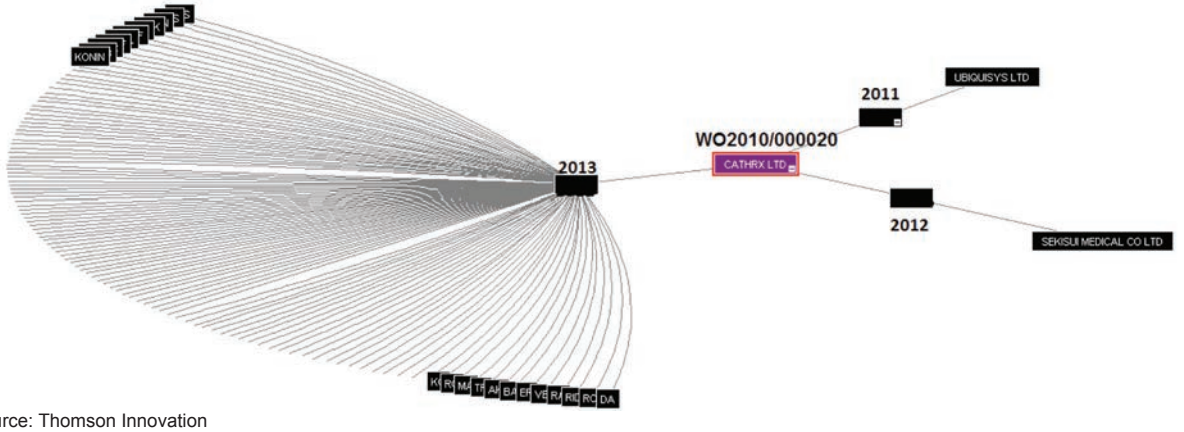
In 2011 and 2012, the CathRx application was only cited once. There was a surge of citations in 2013, with the remaining 112 citations occurring in 2013 (Figure 38).

Figure 37: CathRx specialist catheter



Source: WO 2010/000020

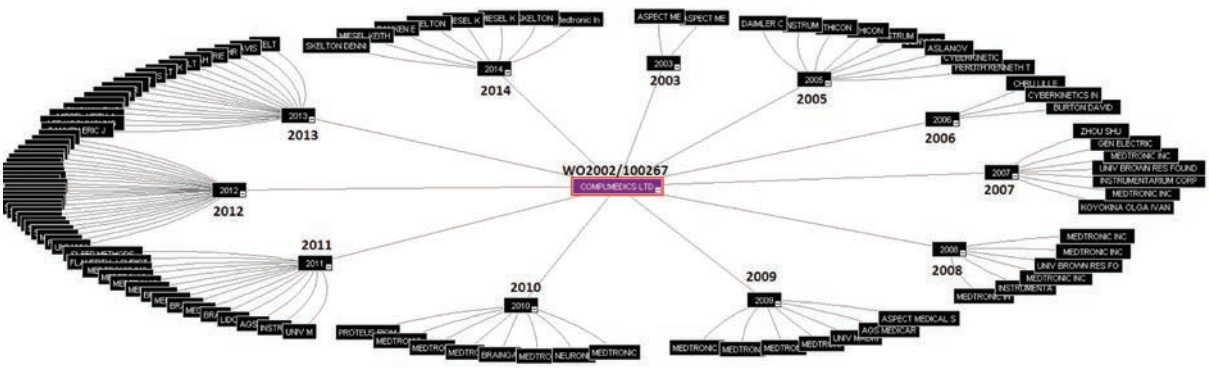
Figure 38: Citation tree for WO 2010/000020 (CathRx)



Source: Thomson Innovation

The third most highly cited PCT is WO 2002/100267, assigned to Compumedics Ltd, with 107 citations. It is directed to an invention that allows for automatic monitoring of patient consciousness using electro-encephalogram (EEG) signals. The PCT application was published in 2002 and it has been cited regularly since then (Figure 39). Unlike the Fermiscan and CathRx inventions, there is no surge in inventive activity associated with this technology, rather a steady stream of applications, signifying that the innovation is in a well-developed area of technology that is experiencing continuous growth.

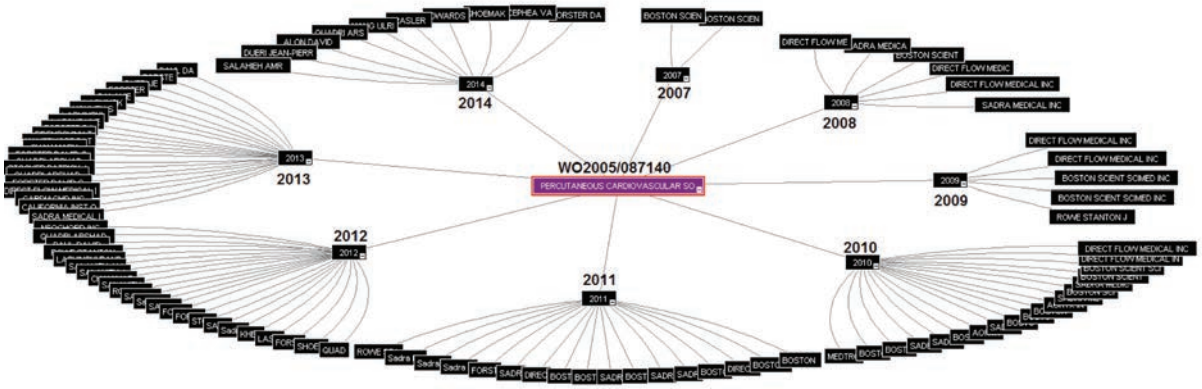
Figure 39: Citation tree for WO 2002/100267 (Compumedics Ltd)



Source: Thomson Innovation

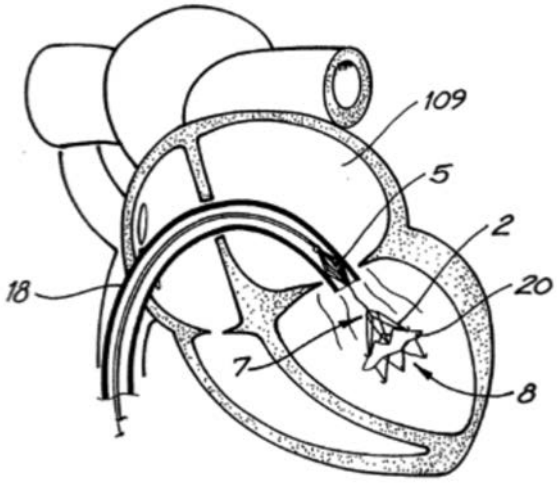
The fourth most highly cited PCT application is WO 2005/087140 by Percutaneous Cardiovascular Solutions PT with 104 citations and is for a percutaneous heart valve prosthesis for treatment of a failed mitral valve. The valve includes a collapsible anchor line which allows a minimally invasive delivery into the patient using a catheter (see Figure 41).The citation distribution for the mitral valve prosthesis, like the Compumedics invention, has maintained a strategically advantageous position in the IP world demonstrating this is an area of continuous development (Figure 40).

Figure 40: Citation tree for WO 2005/087140 (Percutaneous Cardiovascular Solutions)



Source: Thomson Innovation

Figure 41: Percutaneous implantable heart valve



Source: WO 2002/100267

The next two inventions with high citation counts are WO 2004/098405 by Aimedics Pty Ltd and WO 2005/063328 by ResMed. The citation frequency for both inventions are similar to those for the Compumedics and Percutaneous Cardiovascular Solutions inventions showing well developed areas of activity. The product associated with the AiMedics application is HypoMon® a blood sugar monitoring device used during sleep by patients who suffer from Type 1 diabetes. The system sounds an alarm if the person becomes hypoglycemic while they are sleeping. The age bracket for this device is between 10 and 24 years. The ResMed invention is a ventilation device for sufferers of sleep apnea that has a nasal assembly that prevents leakage of flow.

The DPCI data for the top six PCT applications with the highest cited patent families is shown in Appendix T. As the DPCI data relies on Derwent families these applications have corresponding national phase applications in the US and Europe. Furthermore, four of these applications are either assigned or co-assigned to foreign entities; these include Cardiac Dimensions Inc., Whatman Inc., Depuy Spine Inc., and Rita Medical Systems Inc. As the first on the list, WO 2002/100267, also occurs in the highly cited PCT application list it will not be discussed further here.

WO 2002/100240 is assigned to Cardiac Dimensions Inc. who is a specialist in the treatment of heart failure related conditions. In some patients the mitral valve does not seal properly when the heart is pumping and there is leakage back into the left atrium. This implantation technique is an alternative to open heart surgery and uses a catheter to deliver the device and reshape the mitral valve affecting better closure.

WO 2002/072870 is a collaboration between Flinders University and Whatman Inc. It discloses a method of diagnosing genetic disorders such as Galactosemia, a genetic metabolic disorder that prevents individuals from metabolising the sugar galactose. This invention is considered to be cutting edge as it relates to predictive medicine.

WO 2003/034948 by Cook relates to a stent or prosthesis for curved lumens. Aortic aneurysms can occur high in the thoracic aorta. In this region the aorta is curved and placement of a substantially cylindrical prosthesis in a curved region can cause problems. The invention prevents the complications observed in similar devices by using shape memory metals and elastic materials which can change length and be arranged into a curved shape without kinks.

WO 2006/135511 by Depuy Spine Inc. discloses a spinal stabilization device for use in the human spinal column. This technique is an alternative to disc fusion that has traditionally been used to treat degenerated and painful joints but can lead to reduced mobility and stress on adjoining vertebrae.

WO 2002/067797 by Rita Medical Systems Inc. (now a part of Angiodynamics Inc.) discloses a method of surgically treating organ tumours, such as hepatic tumours, by superficially ablating the organ surface using electrodes which project from a housing during use. This method replaces traditional surgery which was considered high risk given risk of also damaging healthy tissue during the procedure.

10. Conclusion

In the medical devices technology area, Australia has a positive relative specialisation index based on applications of PCT applications over the period from January 2001 to May 2012. Australia is ranked eighth in the word sitting between Switzerland and New Zealand.

This positive relative specialisation for Australia is in part based on the contributions of three specialist applicants defining hotspots of activity in the Respiratory, Hearing and Stent areas of medical technology. However, it is the cumulative effect of many applicants who are not considered to be prolific filers that has provided for this positive RSI. In fact, the contribution of single filers (applicants who have not previously filed in the medical devices area in the study period) accounts for approximately 40 per cent of the applications.

This report also identified a steady level of cooperation between Australian and foreign inventors varying from 13 per cent to 24 per cent of the total numbers of PCT applications filed over the time period studied. This cooperation is in part due to collaborations between the top applicants (ResMed, Cochlear and Cook) with foreign based entities. Collaborations between PFROs and industry and universities and industry were also reviewed noting in some instances networks of activity. In the Vision related technologies, the PFRO contribution provided an excellent example of collaborative applicant behaviour.

The technology map based on patent applications mirrors the ANZSIC classes allocated to the medical devices area, however, some areas of specialisation emerge that are not associated with an ANZSIC class. These areas were further analysed by applicants and the following areas emerged: Measuring, Catheters, Stents, and Emergency. Each of these areas of specialisation has a unique applicant profile defined by early entrants, late entrants, steady filers, and interim filers. In some instances the most prolific filer in an area is a PFRO (for example NICTA in the Vision specialisation), in other cases the contribution of many applicants provide for the specialisations observed. Observations made on the qualitative analysis of the entry of new applicants and recent filing activity of established applicants indicates that Vision, Surgical, Electromedical/Diagnostics, Implants, Hearing and Respiratory show some growth whereas Stents shows some decline because of the reduction in number of patents filed by the dominant applicant in this area, Cook.

Patent metrics provide for identification of inventions of value whether that value is one accorded by the applicant or by follow on activity. Where possible these inventions were highlighted in the report providing snapshots of state of the art in various areas of specialisation.

Medical devices are predominantly marketed in North America and Europe. There may be incentive for future investment by both private and public enterprise in the established and emerging ecosystems identified in this report.

Appendix A: Search strategy

Database: OECD, REGPAT database, January 2014

```
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        regpat.regpat_pct_ipc
where regpat_pct_inv_reg.pct_nbr = regpat_pct_ipc.pct_nbr
        and regpat.regpat_pct_ipc.pct_nbr = regpat_pct_app_reg.pct_nbr
        and regpat.regpat_pct_ipc.prio_year > 2000
        and regpat.regpat_pct_ipc.prio_year < 2014
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        or regpat.regpat_pct_ipc.ipc LIKE 'A61C%'
        or regpat.regpat_pct_ipc.ipc LIKE 'A61D%'
        or regpat.regpat_pct_ipc.ipc LIKE 'A61F%'
        or regpat.regpat_pct_ipc.ipc LIKE 'A61G%'
        or regpat.regpat_pct_ipc.ipc LIKE 'A61H%'
        or regpat.regpat_pct_ipc.ipc LIKE 'A61J%'
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        or regpat.regpat_pct_ipc.ipc LIKE 'A61L%'
        or regpat.regpat_pct_ipc.ipc LIKE 'A61M%'
        or regpat.regpat_pct_ipc.ipc LIKE 'A61N%'
        or regpat.regpat_pct_ipc.ipc LIKE 'A62B%'
        or regpat.regpat_pct_ipc.ipc LIKE 'H04R025%')
        and regpat.regpat_pct_inv_reg.ctry_code LIKE 'AU%'
```

Appendix B: Patent classes searched

A61B	Diagnosis; surgery; identification
A61C	Dentistry; apparatus or methods for oral or dental hygiene
A61D	Veterinary instruments, implements, tools, or methods
A61F	Filters implantable into blood vessels; prostheses; devices providing patency to, or preventing collapsing of, tubular structures of the body, e.g. stents; orthopaedic, nursing or contraceptive devices; fomentation; treatment or protection of eyes or ears; bandages, dressings or absorbent pads; first-aid kits
A61G	Transport, personal conveyances, or accommodation specially adapted for patients or disabled persons; operating tables or chairs; chairs for dentistry; funeral devices
A61H	Physical therapy apparatus, e.g. devices for locating or stimulating reflex points in the body; artificial respiration; massage; bathing devices for special therapeutic or hygienic purposes or specific parts of the body
A61J	Containers specially adapted for medical or pharmaceutical purposes; devices or methods specially adapted for bringing pharmaceutical products into particular physical or administering forms; devices for administering food or medicines orally; baby comforters; devices for receiving spittle
A61K	Preparations for medical, dental, or toilet purposes
A61L	Methods or apparatus for sterilising materials or objects in general; disinfection, sterilisation, or deodorisation of air; chemical aspects of bandages, dressings, absorbent pads, or surgical articles; materials for bandages, dressings, absorbent pads, or surgical articles
A61M	Devices for introducing media into, or onto, the body; devices for transducing body media or for taking media from the body; devices for producing or ending sleep or stupor
A61N	Electrotherapy; magnetotherapy; radiation therapy; ultrasound therapy
A62B	Devices, apparatus or methods for life-saving
B01L	Chemical or physical laboratory apparatus for general use
G01N	Investigating or analysing materials by determining their chemical or physical properties
G03B	Apparatus or arrangements for taking photographs or for projecting or viewing them; apparatus or arrangements employing analogous techniques using waves other than optical waves; accessories therefor
G06F	Electric digital data processing
G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for

Appendix C: ANZSIC Class 2411[24]

Division C MANUFACTURING

Subdivision 24 MACHINERY AND EQUIPMENT MANUFACTURING

Group 241 PROFESSIONAL AND SCIENTIFIC EQUIPMENT MANUFACTURING

Class 2411 Photographic, Optical and Ophthalmic Equipment Manufacturing

This class consists of units mainly engaged in manufacturing photographic equipment (except sensitised photographic film, paper, plates or chemicals), optical instruments or equipment, or ophthalmic equipment. Also included are units mainly engaged in grinding optTical lenses.

Primary activities

- Binocular manufacturing
- Camera manufacturing
- Contact lens manufacturing
- Microscope manufacturing
- Ophthalmic article manufacturing
- Optical instrument or equipment manufacturing
- Optical lens grinding
- Spectacle frame manufacturing
- Spectacle lens grinding
- Sunglasses manufacturing
- Telescope manufacturing

[24] Class 2411 Photographic, Optical and Ophthalmic Equipment Manufacturing: http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/1D2D8AE15AD5FB1ECA257B9500133C75?opendocument

Appendix D: ANZSIC Class 2412[25]

Division C MANUFACTURING

Subdivision 24 MACHINERY AND EQUIPMENT MANUFACTURING

Group 241 PROFESSIONAL AND SCIENTIFIC EQUIPMENT MANUFACTURING

Class 2412 Medical and Surgical Equipment Manufacturing

This class consists of units mainly engaged in manufacturing medical, surgical or dental equipment, including dentures.

Primary activities

- Artificial eye manufacturing
- Artificial joint manufacturing
- Artificial limb manufacturing
- Dental amalgam manufacturing
- Dental chair manufacturing (fitted with mechanical device)
- Dental instrument or equipment manufacturing
- Dental plaster or cement manufacturing
- Denture manufacturing
- Electromedical equipment manufacturing
- First aid equipment manufacturing
- Hearing aid manufacturing
- Hypodermic needle or syringe manufacturing
- Magnetic resonance imaging (medical) equipment manufacturing
- Medical diagnostic apparatus manufacturing
- Medical equipment manufacturing
- Medical ultrasound equipment manufacturing
- Orthotics (arch support) manufacturing
- Pacemaker manufacturing
- Respirator manufacturing
- Surgical equipment manufacturing
- Thermometer, medical, manufacturing
- Veterinary instrument manufacturing

[25] Class 2412 Medical and Surgical Equipment Manufacturing:
http://www.abs.gov.au/AUSSTATS/abs@.nsf/0/D8AA952974A7D82CCA25711F00146F8F?opendocument

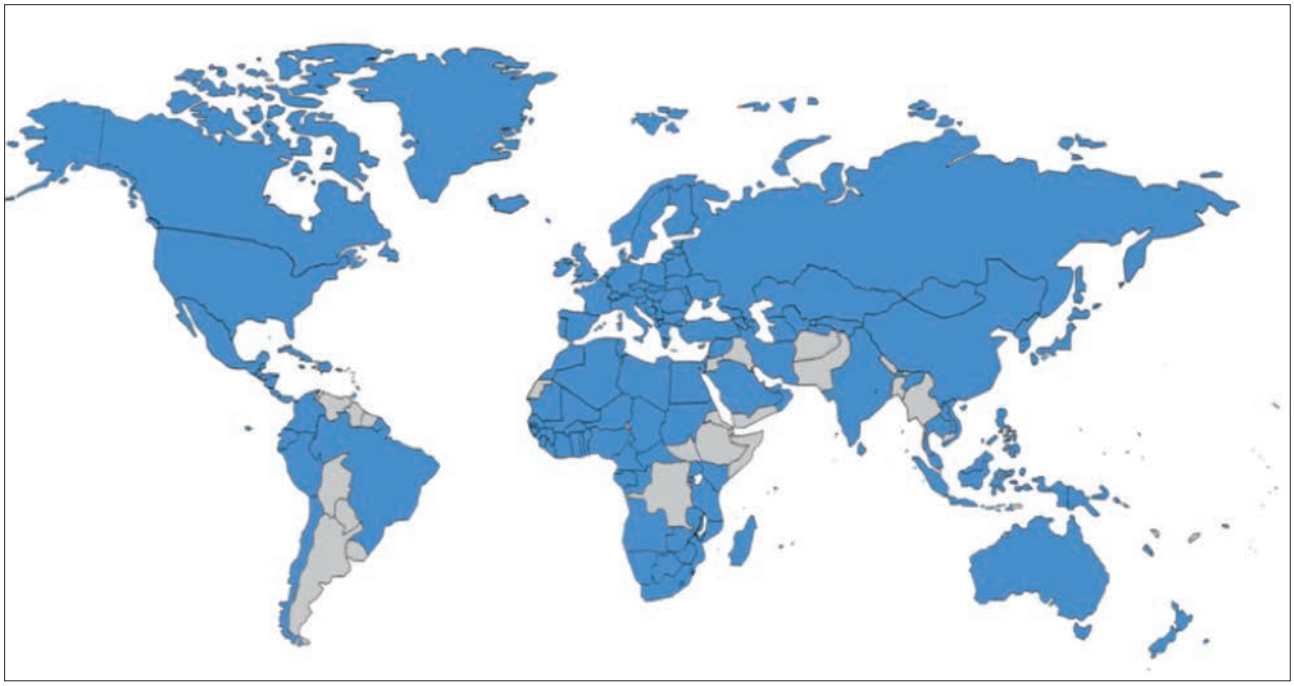
Appendix E: Technology correspondence

Technology grouping	Technology classification	IPC mark	Description and ANZSIC correspondence
Vision	Vision	A61F009 A61F002/14 A61F002/16 A61B003 G02C G02B	includes class 2411 activities relating to contact lenses, ophthalmic lenses, and eye-related surgery or therapies and class 2412 activity 'Artificial eye manufacturing'
Implants	Implantable Joints	A61F002/28 A61F002/3 A61F002/4 A61L027/52	includes class 2412 activity 'Artificial joint manufacturing'
	Prostheses	A61F002/5 A61F002/6 A61F002/7 A61F002/80 A61F003 A61F004	includes class 2412 activity 'Artificial limb manufacturing'
Dental	Dental	A61G015 A61C	includes class 2412 activities 'Dental amalgam manufacturing', 'Dental chair manufacturing (fitted with mechanical device)', 'Dental instrument or equipment manufacturing', 'Dental plaster or cement manufacturing' and 'Denture manufacturing'
Hearing	Hearing	H04R025 H04R001/10 A61F002/18 A61F011 H04R001 H04R003	includes class 2412 activity 'Hearing aid manufacturing'
Syringes/ Needles	Syringes/ Needles	A61M003 A61M005 A61C002	includes class 2412 activity 'Hypodermic needle or syringe manufacturing'

Technology grouping	Technology classification	IPC mark	Description and ANZSIC correspondence
Electromedical / Diagnostic	Electromedical	A61B005/04 A61N001 A61N002 A61N005 A61B006 A61K049/04	includes class 2412 activity 'Electromedical equipment manufacturing', corresponds to IPC marks that defined ECG, EKC, EEG, magnetotherapy and radiation therapy
	Magnetic Imaging	A61B050/55	Includes class 2412 activity 'Magnetic resonance imaging (medical) equipment manufacturing'
	Ultrasound	A61B008 A61N007	includes class 2412 activity 'Medical ultrasound equipment manufacturing'
Stents	Stents	A61F002/00 A61F002/01 A61F002/24	area of specialisation as identified on ThemeScape map (no direct ANZSIC correspondence)
Catheters	Catheters	A61M025 A61F029	an area of specialisation as identified on ThemeScape map (no direct ANZSIC correspondence)
Veterinary	Veterinary	A61D	includes class 2412 activity 'Veterinary instrument manufacturing'
Emergency	First Aid	A61F013 A61F015 A61F017	includes class 2412 activity 'First aid equipment manufacturing'
	Emergency/ Life Saving	A61G001 A61G003 A61G005 A61G007 A61G009 A61G010 A61G011/00 A61G012/00 A62B	Emergency (Life-Saving) corresponds with major IPC group searched (no direct ANZSIC correspondence)
Respiratory	Respiratory	A61B005/08 A61M015 A61M016 A61H031/00	includes class 2412 activity 'Respirator manufacturing'
Measuring	Measuring	A61B005/02 A61B005/32	an area of specialisation as identified on ThemeScape map. The group identifies inventions that relate to measurement e.g. pulse, blood, cardiac function etc. (no direct ANZSIC correspondence)

Technology grouping	Technology classification	IPC mark	Description and ANZSIC correspondence
Surgical	Surgical	A61B001 A61B017 A61B018 A61B019 A61G013 A61L017 A61L024 A61L027 A61L028 A61L031	includes class 2412 activity ‘Surgical equipment manufacturing’
	Orthopaedic	A61F005	Non-surgical: an area of specialisation as identified on ThemeScape map (no direct ANZSIC correspondence), inventions include: bracing devices, knee braces, limb protection devices, lumbar traction devices, medical rehabilitation apparatus, and splints
Other Medical	Other Medical	A61F006 A61B005/01 G01K005/22 G01K013/00 A61F005/14 A43B007/14 A61B007 A61N001/365 A61B010 A61B013 A61B016 A61L002 A61L009 A61L011 A61L012	includes class 2412 activities ‘Medical equipment manufacturing’, ‘Orthotics (arch support) manufacturing’, ‘Thermometer, medical, manufacturing’, ‘Medical diagnostic apparatus manufacturing’, ‘Pacemaker manufacturing’ and further devices including contraceptives, stethoscopes, disinfecting or sterilising instruments

Appendix F: Complete list of PCT contracting states



two-letter code	name of state
AE	United Arab Emirates
AG	Antigua and Barbuda
AL	Albania
AM	Armenia[27]
AO	Angola
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BH	Bahrain[27]
BJ	Benin
BN	Brunei Darussalam
BR	Brazil
BW	Botswana

two-letter code	name of state
BY	Belarus[27]
BZ	Belize
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CL	Chile[27]
CM	Cameroon
CN	China[28, 29]
CO	Colombia
CR	Costa Rica
CU	Cuba[27]
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
DM	Dominica

two-letter code	name of state
DO	Dominican Republic
DZ	Algeria[27]
EC	Ecuador
EE	Estonia
EG	Egypt
ES	Spain
FI	Finland[30]
FR	France[27, 31]
GA	Gabon
GB	United Kingdom[32]
GD	Grenada
GE	Georgia[27]
GH	Ghana
GM	Gambia
GN	Guinea
GQ	Equatorial Guinea
GR	Greece
GT	Guatemala
GW	Guinea-Bissau
HN	Honduras
HR	Croatia
HU	Hungary[27]
ID	Indonesia[27]
IE	Ireland
IL	Israel
IN	India[27]
IR	Islamic Republic of Iran
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan[27]
KM	Comoros
KN	Saint Kitts and Nevis
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakhstan[27]
LA	Lao People's Democratic Republic
LC	Saint Lucia[27]
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
LY	Libya
MA	Morocco
MC	Monaco
MD	Republic of Moldova[27]
ME	Montenegro
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MT	Malta[27]
MW	Malawi
MX	Mexico
MY	Malaysia[27]
MZ	Mozambique[27]
NA	Namibia
NE	Niger
NG	Nigeria
NI	Nicaragua
NL	Netherlands[33]
NO	Norway[30]
NZ	New Zealand
OM	Oman[27]

two-letter code	name of state
PA	Panama
PE	Peru
PG	Papua New Guinea
PH	Philippines
PL	Poland[30]
PT	Portugal
QA	Qatar[27]
RO	Romania[27]
RS	Serbia[34]
RU	Russian Federation[27]
RW	Rwanda
SA	Saudi Arabia
SC	Seychelles
SD	Sudan
SE	Sweden[30]
SG	Singapore
SI	Slovenia
SK	Slovakia
SL	Sierra Leone
SM	San Marino
SN	Senegal
ST	Sao Tome and Principe

two-letter code	name of state
SV	El Salvador
SY	Syrian Arab Republic
SZ	Swaziland
TD	Chad
TG	Togo
TH	Thailand[27]
TJ	Tajikistan[27]
TM	Turkmenistan[27]
TN	Tunisia[27]
TR	Turkey
TT	Trinidad and Tobago
TZ	United Republic of Tanzania
UA	Ukraine[27]
UG	Uganda
US	United States of America[36,37]
UZ	Uzbekistan[27]
VC	Saint Vincent and the Grenadines[27]
VN	Viet Nam
ZA	South Africa[27]
ZM	Zambia
ZW	Zimbabwe

[26] All PCT Contracting States are bound by Chapter II of the PCT relating to the international preliminary examination.

[27] With the declaration provided for in PCT Article 64(5).

[28] Applies also to Hong Kong, China with effect from 1 July 1997.

[29] Not applicable to Macau, China.

[30] With the declaration provided for in PCT Article 64(2)(a)(ii) .

[31] Including all Overseas Departments and Territories.

[32] The United Kingdom extended the application of the PCT to the Isle of Man with effect from 29 October 1983.

[33] Ratification for the Kingdom in Europe, the Netherlands Antilles and Aruba. The Netherlands Antilles ceased to exist on 10 October 2010. As from that date, the PCT continues to apply to Curaçao and Sint Maarten. The PCT also continues to apply to the islands of Bonaire, Sint Eustatius and Saba which, with effect from 10 October 2010, have become part of the territory of the Kingdom of the Netherlands in Europe.

[34] Serbia is the continuing State from Serbia and Montenegro as from 3 June 2006.

[35] Date of ratification of the Soviet Union, continued by the Russian Federation as from 25 December 1991.

[36] With the declarations provided for in PCT Articles 64(3)(a) and 64(4)(a).

[37] Extends to all areas for which the United States of America has international responsibility.

Appendix G: Collaboration matrix of applicants with the top 24 inventors

Applicant	Hartley, D. E.	Kwok, P. R.	Parker, J.	Miljasevic, Z.	Ho, A.	Ducke, W. D.	Brown, M. L.	Selvarajan, K.	Veliss, L. J.	Farrugia, S.P.	Henry, R. E.	Anderson, N. L.	Davidson, A.S.	Dadd, F.	Gibson, P.	Hitchcock, R. G	Chong, E.	Frater, R.H.	Kiehne, B. L.	Lithgow, P. D.	Meskens, W.	Virr, A.	Walsh, A.	Kenyon, B. J.
ResMed Ltd		42						19	18	20	18		17			14		10		13		12		14
Cook Inc	75					19	16																	
Cochlear Ltd			40	1										16	16						15			
CathRx Ltd				9								15					13							
Cleveland Clinic Foundation	8					2	5																	
Global Medisafe Holdings Ltd																							12	
Occupational & Medical Innovations Ltd																			12					
MED Institute Inc	6					3	1																	
Columna Pty Ltd				9																				
Brien Holden Vision Institute					9																			
Institute of Eye Research					9																			
VisionCRC Ltd					8																			
Map Medizin Technologie Gmbh		1						2	1		1					1								
Neopraxis Pty Ltd				6																				
Advanced Metal Coatings Pty Ltd												2					2							
Emisphere Technologies Inc		1							1							1				1				
Neuromonics Pty Ltd																		4						
Acu Rate Pty Ltd				3																				
Morgan Meditech Inc																							3	
Neustent Pty Ltd				3																				
PAFtec Holdings Pty Ltd																						3		
Spinecell Pty Ltd				3																				
Chelsea Brands Pty Ltd																			2					
Murray Vascular Pty Ltd				2																				
National ICT Australia Ltd			2																					
Adventus Technology Inc					1																			
Bivascular Technologies Pty Ltd				1																				
Colocare Holdings Pty Ltd																		1						
CSIRO							1																	
Cooper Vision Inc					1																			
Ocular Sciences Inc					1																			
Precision Foam Technologies Pty Ltd									1															
Saluda Medical Pty Ltd			1																					
Signostics Ltd			1																					
Silverbrook Research Pty Ltd																				1				
Southmedic Inc																			1					
University of California	1																							

Source: DWPI

Appendix H: PFRO PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CSIRO	3	4	4	4	3	7	5	6	3	2	5	
National ICT Australia					1			2	8	1	10	
Baker IDI Heart and Diabetes Institute		1		3	3	3		1	1		2	
Brien Holden Vision Insitute		1	1			2	3	1	1	1	2	2
The Bionics Institute		1	1			1	1	1	4	2	3	
Lions Eye Institute	4	3	1	1					1			
HEARing CRC	1	1		1		1		1	2	1	1	
Sydney West Area Health Service	1	1	1	3	3							
Vision CRC			2			3	2	1		1		
Women's and Children's Hospital	1	1	2			2				1		
Murdoch Childrens Research Institute								1	1	1	2	
Northern Sydney & Central Coast Area Health		1	2				2					
Australian Centre for Advanced Medical Tech.	1					2		1				
Australian Nuclear Science and Technology Org.					1			1		1	1	
The Royal Alexandra Hospital for Children	3							1				
The Sydney Children's Hospitals Network	1							1			1	
Brain Research Institute					1					1		
Flinders Medical Centre				1						1		
CRC for Polymers								1	1			
St. Vincent's Hospital Melbourne							1			1		
Australasian CRC Interaction Design Pty Ltd					1							
Florey Institute of Experimental Physiology	1											
The Ear Science Institute of Australia											1	
Walter and Eliza Hall Inst. of Medical Research	1											

Source: DWPI

Appendix I: University PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
University of Queensland	3	3	4	5	4	6	3	11	5	2	3	1
University of Sydney	3		3	1		6	8	8	2	1	3	1
Queensland University of Technology		3	2	4	5	5	6	3	4	1	1	1
Monash University	2	5	4	1	1		2	1	8		3	
University of New South Wales	2	2	3	3	1		2	1	3	1	4	
University of Melbourne	1	1	1			2	1	3	2	1	4	
University of Technology Sydney	2	3	3				1		4		3	
Australian National University	1		1		1		1	4	1	1	1	
University of Western Australia	1			1		1	2	1		1	1	
University of South Australia				1	1			2		2	1	
University of Wollongong	2	2				1			2			
Curtin University				1	1		1		1	1		
Macquarie University	1		1	1				1	1			
University of Adelaide		1				1					1	2
University of Newcastle	1							2		1		
Swinburne University of Technology			1		1		1				1	
Flinders University	1	1	1									
James Cook University		1					1				1	
Royal Melbourne Institute of Technology			1						1	1		
University of Tasmania	2	1										
La Trobe University				1		1						
University of New England				1							1	
Murdoch University					1							
University of Western Sydney								1				

Source: DWPI

Appendix J: Patents where SMEs collaborate with other SMEs

Publication number	Applicants	Technology specialisation	Title of invention
WO2003009891	AFRA DESIGN PTY LTD; BIOMD LTD	SYRINGE/ NEEDLES	Single use syringe for medical applications, has forward and reverse movement prevention units which are located in resilient locking unit and are enabled and disabled respectively during forward movement of needle barrel
WO2003024514	ADVENT PHARM PTY LTD; GEORGE MEDICA PTY LTD	RESPIRATORY	Inhaler for delivering metered doses of powdered medicament, comprising compartments containing doses of medicament and closed by sealing layer, and lever to displace compartments one by one into line with inhalation aperture
WO2003092392	LOGISTIC SOLUTIONS LTD; STEP SCI LTD	OTHER	Ultraviolet radiation treatment of unwanted microorganisms in water and fresh fruits and vegetables, includes establishing vortex turbulated flow of water and generating ultraviolet radiation flow
WO2004018024	AFRA DESIGN PTY LTD; BIOMD LTD	SYRINGE/ NEEDLES	Needle assembly includes sheath mounted on elongate needle mount for reciprocal axial movement between forward position where sheath covers needle and rearward position where needle is exposed
WO2004026151	OCCUPATIONAL & MEDICAL INNOVATIONS LTD; SOUTHMEDIC INC	SURGICAL	Safety blade assembly for surgical scalpel, has guard with attachment that locks blade to guard as assembly is being attached to handle such that guard has removable tab having portion which can be gripped by user
WO2004083941	HOGAN PTY LTD MARTIN; OPHTHALMIC ENG PTY LTD	EYE	Modular eyewear system for protective headwear, includes magnetic mounting unit which detachably fixes optical instrument to front of frame
WO2004093706	QLICKSMART PTY LTD; QUICKSMART PTY LTD	SURGICAL	Scalpel blade remover for removing blade from tang of surgical scalpel, has actuator legs that separate scalpel blade from scalpel tang, and detents that retain actuator in distal position, such that blade is retained when tang is withdrawn

WO2004098407	INNER VISION BIOMETRICS PTY LTD; RESONANCE HEALTH ANALYSIS SERVICES PTY	MEDICAL IMAGING	Magnetic resonance imaging radio frequency signal intensities spatial variation estimating method for use in clinical application, involves fitting mathematical model to measured intensities of medium to obtain variation estimate
WO2005065528	ING LYTZEN AS; VISION INSTR PTY LTD	EYE	Fundus camera for retinal disease diagnosis, has focus aid mark projecting system including moving focus aid mark focusing lens that moves so as to move focus of focus aid mark so that mark is coplanar with focal plane of imaging system
WO2006007629	AFRA DESIGN PTY LTD; HELIRO PTY LTD	SYRINGE/ NEEDLES	Vertical cannula device for transcutaneous introduction or removal of fluid into or from patient, includes top piece having cannula needle slidable between retracted position and protruded position
WO2006012699	COUNCIL KANGAN BATMAN INST TECH & FURTHER EDUCATION; JOHANSON NOMINEES PTY LTD	EMERGENCY (LIFE-SAVE)	Dual mode wheelchair for use in indoor environments such as homes and offices, has fore and rear shafts positioned so as to define short and long wheelbase, in indoor maneuverable and travel modes respectively
WO2006032094	BIOSYSTEMS ENG PTY LTD; CAPLOP PTY LTD	DENTAL	Ground-engaging apparatus for e.g. tilling, and non-till seed planting, includes primary spring which applies first force to support plate, and secondary spring which applies second force to two arms
WO2006119584	CUSTOMVIS PLC; CV LASER PTY LTD	EYE	Patient`s eye position monitoring method for use during ophthalmic laser ablation surgery, involves recording values for light scattered, respectively, by sclera and iris in illuminated region
WO2008077178	SEPT PTY LTD; SSPT PTY LTD	ELECTROMEDICAL	Method of assessing effectiveness of audiovisual, visual or audio advertisement involves calculating steady state visually evoked potential amplitudes from electroencephalogram signals obtained from scalp sites of subjects

WO2010108228	CUSTOMVIS PLC; CV LASER PTY LTD	EYE	Optical apparatus for retinal photography, has multiple lens components and illumination source which illuminate retina of eye in front of nose region of housing
WO2002058553	HEALTH SMARTS GROUP PTY LTD; SONOMEDICAL PTY LTD	MEASURING; OTHER	Heart beat determination for use to determine the heart rate of a human being or animal involves sensing body sounds and digitizing them into electrical signals, and emphasizing the heart sound maxima relative to noise by noise filtering
WO2003020403	GRADIPORE LTD; LIFE THERAPEUTICS	MEASURING; OTHER	Electrophoresis system useful for renal dialysis of humans, includes ion-permeable barrier, blood or plasma cooler, dialysate provider and blood or plasma pumping element
WO2005065527	CUSTOMVIS PLC; CV LASER PTY LTD	EYE; MEDICAL IMAGING	Determination and tracking method of eye position, involves utilizing two wavelength components of multiple wavelength linear zone that traverses limbus of eye, to obtain profile of whiteness and/or redness across zone
WO2005089831	GLENORD PTY LTD; Q-STAT PTY LTD	SYRINGE/ NEEDLES; OTHER	Syringe for injecting drug, includes limit catch provided on plunger and preventing plunger from being fully depressed and disengaging first latching mechanism from retaining mechanism on initial actuation of plunger
WO2005096090	CUSTOMVIS PLC; CV LASER PTY LTD	SURGICAL; EYE	Laser beam harmonic conversion apparatus for laser ablation apparatus for e.g. performing refractive eye surgery comprises hermetically sealed chamber, port for evacuating chamber and frequency conversion crystals in optical path
WO2011003135	ULTIMATE MEDICAL PTY LTD; UMEDAES LTD	EMERGENCY (LIFE-SAVE); RESPIRATORY	Artificial airway used in surgical procedures or emergencies to establish uninterrupted airway for patient, has cuff with anterior walls and posterior wall sealingly engaging about glottic opening and posterior pharyngeal wall of patient

WO2012061869	CHIMDEN MEDICAL PTY LTD; ULTIMATE MEDICAL PTY LTD	CATHETERS; OTHER	Valve for use with intravenous liquid container/circuit for preventing entry of air into patient's circulation via intravenous catheter, has arrangement that is provided such that head of liquid within container unseats diaphragm from seat
WO2005107847	CHELSEA BRANDS PTY LTD; OCCUPATIONAL & MEDICAL INNOVATIONS LTD	CATHETERS; SYRINGE/ NEEDLES; OTHER	One way valve assembly for catheter, comprises valve positioned within flow path, and which is movable between open position enabling fluid to flow towards outlet of valve, and closed position preventing backflow of fluid through inlet
WO2007025336	CHIMDEN MEDICAL PTY LTD; ULTIMATE MEDICAL PTY LTD	RESPIRATORY; SURGICAL; OTHER	Oxygenating device has coupling spigot comprising female leur socket for receipt in male leur connector of endotracheal tube or laryngeal mask
WO2003056228	CAITIN INC; PAX SCI INC; PAX STREAMLINE INC	MEASURING; RESPIRATORY; STENTS; SYRINGE/ NEEDLES; OTHER	Fluid flow controller comprising active surface whose shape conforms to at least one logarithmic curve
WO2005082440	OSPREY MEDICAL INC; V-KARDIA PTY LTD	CATHETERS; ELECTORMEDICAL; STENTS; SURGICAL; OTHER	Isolation of cardiac circulation from systemic circulation comprises occluding flow between coronary sinus and right atrium, locating venous collection device, using support structure to maintain patency and providing artificial flow path
WO2005046475	INT PATENT OWNERS CAYMAN LTD; KCAT INVESTMENTS PTY LTD	IMPALNTS; SURGICAL	Gauge for hip replacement surgery, has plumb bob that is mounted to housing using universal joint such that bob is under influence of local gravitational field and rotatable relative to housing

Appendix K: Patents where SMEs collaborate with other types of entities

Publication number	Applicants	Collaborator	Technology specialisation	Title of invention
WO2003004056	IMMUNE SYSTEM THERAPEUTICS LTD; PACMAB LTD; UNIV SYDNEY TECHNOLOGY	University	OTHER	Treating kappa-type multiple myeloma in a subject by administering a K121-like antibody not conjugated to a toxin or a cytolytic agent
WO2004027474	POLY OPTICS AUSTRALIA PTY LTD; UNIV SYDNEY TECHNOLOGY	University	DENTAL; OTHER	Light emitting device for dental filling application, has transparent diffuser particles with low back reflectance and low absorbance, that scatter light from one end of core towards other end
WO2004099808	CANADA MIN NAT RES COUNCIL CANADA; INST MAGNETIC RESONANCE RES; NORTH SYDNEY AREA HEALTH SERV	PFRO	ELECTROMEDICAL; MEDICAL IMAGING	Pain component detection method e.g. for chronic pain, involves comparing obtained MR spectroscopic data with reference data, to detect presence of pain component
WO2007029041	IMPERIAL INNOVATIONS LTD; UNIV SOUTHAMPTON	University	RESPIRATORY; OTHER	Use of interferon lambda, in manufacturing a medicament for the treatment of respiratory disorder or allergic disorder
WO2008011100	BAKER MEDICAL RES INST; OSPREY MEDICAL INC	PFRO	CATHETERS; OTHER	Occlusion treatment in first coronary artery of patient involves admitting therapeutic agent to first coronary artery to treat microvasculature obstructions at target cardiac tissue site distal to site of occlusion

Publication number	Applicants	Collaborator	Technology specialisation	Title of invention
WO2003082914	UNIV QUEENSLAND; VENOMICS PTY LTD	University	FIRST AID; SURGICAL; OTHER	New snake venom protease preparation useful in promoting hemostasis and preventing blood loss such as during surgery, in treating wounds resulting from accidents and other types of injury or trauma, or as a surgical sealant or adhesive
WO2004045720	MADISTERIM CO LTD; MEDI-STREAM PTY LTD; NOVARTIS AG	Big	EMERGENCY (LIFE-SAVE); RESPIRATORY; OTHER	Breathing apparatus for medicating an air stream comprises a medication chamber adapted to store and discharge a therapeutic agent and a releaser for discharging the agent from the chamber
WO2004100844	ENTTEX PTY LTD; FRANZ PTY LTD BURKHARD	University associated	HEARING; SURGICAL, OTHER	Hand-held and hand-operable pressure changing device used to treat ear, has diaphragm actuated to increase or decrease air pressure in air chamber and transmit changed air pressure through tube and into ear canal when ear piece is inserted
WO2005019440	BIOLOGICAL RESOURCES PTY LTD; NORTH SYDNEY AREA HEALTH SERV	PFRO	VETERINARY; SURGICAL, OTHER	Enhancing embryo viability, involves administering combination of inhibitor of p53 or p53-associated pathway, p53 inhibitor and growth promoting agents, to embryo, oocytes, sperm, female animal or male animal
WO2005046782	MINAS CORONEO; TRANSCEND MEDICAL INC	Private Applicant	EYE; SURGICAL; SYRINGE/NEEDLES	Flexible ocular device used for intraocular surgery of patient with glaucoma, has drainage tube opening facing the disc at one end, provides aqueous pressure regulation when device is implanted into the eye
WO2007022592	BAKER MEDICAL RES INST; OSPREY MEDICAL INC	PFRO	CATHETERS; STENTS; SYRINGE/NEEDLES	Support device for blood vessel of human subject, has elongate structure supporting vessel wall over length on elongate portions, where distance between adjacent elongate portions is lesser than catheter diameter

Appendix L: Hearing PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cochlear Ltd	18	20	7	5	4	9	25	67	14	14	21	6
Newsouth Innovations Pty Ltd	1	2	1	3	1		2	1	2	1	4	
Bionics Inst		1	1			1	1	1	4	2	3	
HEARing Crc	1	1		1		1		1	2	1	1	
Dynamic Hearing Pty Ltd			3	1		1	1					
Neuromonics Pty Ltd			1		1			2				
Techmin Pty Ltd	1				3							
Franz Pty Ltd Burkhard			1							1	1	
Phonak Ag					1	1	1					
Sensear Pty Ltd				1			1		1			
Era Cent Pty Ltd		1		1								
Neurostimulation Devices&Technology Pt									1	1		
Vast Audio Pty Ltd			2									
Audiology Innovations Pty Ltd						1						
Australia Hears Pty Ltd									1			
Blamey&Saunders Hearing Pty Ltd									1			
Ear Sci Australia Inst											1	
Enttex Pty Ltd			1									
Gsmo Pty Ltd						1						
Loud & Clear Safety Pty Ltd								1				
Med-El Elektromedizinische Geraete Gmbh					1							
Perry Microtube Pty Ltd	1											
Sound Safety Pty Ltd			1									
Widex As										1		

Source: DWPI

Appendix M: Respiratory PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Resmed Ltd	7	10	18	24	45	30	13	13	22	13	23	2
Map Medizin Technologie Gmbh		1	3	1	1		1					
PulmoSonix Pty Ltd		1		1	2				1			
Saime					3		2					
Australian Cent Advanced Medical Technol	1					2		1				
Plastiflex Group							1		2		1	
Sonomedical Pty Ltd	1						1			1	1	
Paftec Holdings Pty Ltd									1		2	
Advent Pharm Pty Ltd	1									1		
Diagnoseit Pty Ltd			1			1						
Infamed Ltd	1				1							
Injet Digital Aerosols Ltd	1		1									
Intelligent Medical Technologies Pty Ltd					1	1						
A Capital Idea Act Pty Ltd						1						
Alcolizer Pty Co Ltd										1		
Amcor Ltd						1						
Asap Breatheassist Pty Ltd		1										
Be Well Ip Pty Ltd						1						
Benson Medical Services Pty Ltd				1								
Bidibots Pty Ltd								1				
Blackwood & Son Ltd J								1				
Emisphere Technologies Inc			1									
Flexible Plastic Belgium Sa							1					
Intersection Medical Inc					1							
Madisterim Co Ltd		1										
Medical Dev Int Ltd										1		
Paranta Biosciences Pty Ltd	1											
Precision Foam Technologies Pty Ltd								1				
Rural Ambulance Victoria		1										
Shanghai Dasheng Health Prod Mfr Co Ltd								1				
Sleepzone Cpap Prod				1								
Telethon Inst Child Health					1							
Ventific Holdings Pty Co Ltd										1		
Visecor Pty Ltd												1

Source: DWPI

Appendix N: Stents PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cook Inc	4	14	9	8	5	16	7	6	6	7		1
Cleveland Clinic Found				1	1	2		2	1	1		
Med Inst Inc		1				1		1	1	2		
Polynovo Biomaterials Pty Ltd		1		2		1	1					
Neustent Pty Ltd						1		2				
Ami Agency Medical Innovations Gmbh						2						
Murray Vascular Pty Ltd								1	1			
Allvascular Pty Ltd						1						
Bivascular Technologies Pty Ltd						1						
Endosystems Llc	1											

Source: DWPI

Appendix O: Surgical PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Depuy Int Ltd	2	3	2	4	6	2		1		1	1	
Occupational & Medical Innovations Ltd	3	2		1	3	1	2					
Australian Surgical Design & Mfr Pty Ltd	4		2	1	1	2						
Columna Pty Ltd		1			2	5	1	1				
Continence Control Systems Int Pty Ltd				1	4	3	1		1			
Ventracor Ltd		1	6	2	1							
Novapharm Res	2		3		2	1		1				
Sunshine Heart Co Pty Ltd	1	2	4			1				1		
Ventrassist Pty Ltd	1	1	1		2		4					
Cleveland Clinic Found				1	1	2		2	1	1		
Thoratec Corp	1	1	3	1	2							
Ethicon Endo-Surgery Inc		1			1	4	1					
Neopraxis Pty Ltd		6	1									
Sdgi Holdings Inc			3	2	1			1				
Boston Sci Scimed Inc					2	3		1				
Portland Orthopaedics Ltd	2	1			1	1	1					
Endogene Ltd	1						2	1	1			
Osprey Medical Inc				1	1	2					1	
Polynovo Biomaterials Pty Ltd		1		2		1	1					
Ssb Technology Pty Ltd						1	1	1	1		1	
Ultimate Medical Pty Ltd		1	1		1				1	1		
Customvis Plc				2	1				1			
Cv Laser Pty Ltd				2	1				1			
Dc Devices Inc						1			1	1	1	
Globetek 2000 Pty Ltd										4		
Ludwig Inst Cancer Res	1		1						1		1	
Beeley Pty Ltd A H								3				
Bivacor Pty Ltd									2		1	
Cellixe Pty Ltd							1		2			
Cpl Holdings Pty Ltd										2	1	
Ellysian Ltd					1	2						
Int Patent Owners Cayman Ltd	1		2									
Medsell Pty Ltd						2		1				
Medtronic Inc			1				1		1			
Mercer Technologies Ltd					1				2			
Pod Ip Pty Ltd				1		1			1			
Silesco Pty Ltd						1		2				
Whiteley Ind Pty Ltd				1			1			1		
Aesthetic Devices Pty Ltd						1		1				
Ams Res Corp						1	1					
Austofix Group Ltd								2				
Avastra Ltd				1	1							
Bhc Pharm Pty Ltd					1	1						
Carey Tasca Pty Ltd		1								1		
Covidien Ag	1	1										
Kvinno Cent Pty Ltd		1				1						
Milvella Pty Ltd		1		1								
Multigate Medical Prod Pty Ltd								1	1			
Murray Vascular Pty Ltd								1	1			
Sam Bracing Pty Ltd							1					1
Sherwood Services Ag	1	1										
Surgipod Pty Ltd				1					1			
Umedaes Ltd									1		1	
Vascular Enhancement Technology Pty Ltd					1	1						
Verigen Ag	1	1										
Viater Medical Pty Ltd						1	1					

Source: DWPI

Appendix P: Implants PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Depuy Int Ltd	2	3	2	4	6	2		1		1	1	
Nat Ict Australia Ltd					1			2	8	1	10	
Newsouth Innovations Pty Ltd	1	2	1	3	1		2	1	2	1	4	
Warsaw Orthopedic Inc	1		4	2	3			1	2		1	
Australian Surgical Design & Mfr Pty Ltd	4		2	1	1	2						
Columna Pty Ltd		1			2	5	1	1				
Continence Control Systems Int Pty Ltd				1	4	3	1		1			
Thoratec Corp	1	1	3	1	2							
Neopraxis Pty Ltd		6	1									
Sdgi Holdings Inc			3	2	1			1				
Boston Sci Scimed Inc					2	3		1				
Dynamic Hearing Pty Ltd			3	1		1	1					
Med Inst Inc		1				1		1	1	2		
Portland Orthopaedics Ltd	2	1			1	1	1					
Saluda Medical Pty Ltd								1		1	4	
Aortech Int Plc				1		3			1			
Polynovo Biomaterials Pty Ltd		1		2		1	1					
Atlax Pty Ltd								2	2			
Prosthexis Pty Ltd										2	2	
Spinecell Pty Ltd		1			1	2						
Synthes Gmbh		1	1					2				
Techmin Pty Ltd	1				3							
Bivacor Pty Ltd									2		1	
Ellysian Ltd					1	2						
Int Patent Owners Cayman Ltd	1		2									
Silesco Pty Ltd						1		2				
Smith & Nephew Inc								2		1		
Ams Res Corp						1	1					
Celxcel Pty Ltd				1							1	
Concept Design & Dev Llc							1				1	
Heart Assist Technologies Pty Ltd	1		1									
Intigo Giselle Nominees Pty Co Ltd										2		
Neurostimulation Devices&Technology Pt									1	1		
Nuvasive Inc					2							
Orthoplan Pty Ltd				1			1					
Osteotech Inc	1		1									
Percutaneous Cardiovascular Solutions Pt				1				1				
Perth Bone & Tissue Bank Inc		1						1				
Zimmer Gmbh				1							1	

Source: DWPI

Appendix Q: Electromedical/Diagnostics PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Impedimed Ltd		2		2	6	2	5	3	3	1	1	
Compumedics Ltd	2	2	2	3	4	2	3		3	1		
Nat Ict Australia Ltd					1			2	8	1	10	
Newsouth Innovations Pty Ltd	1	2	1	3	1		2	1	2	1	4	
Signostics Ltd					1	3	7	5	1			
Emotiv Systems Pty Ltd						2	5				1	
Cortical Pty Ltd			2		1	3				1		
Neopraxis Pty Ltd		6	1									
Boston Sci Scimed Inc					2	3		1				
Saluda Medical Pty Ltd								1		1	4	
Brc Ip Pty Ltd							1	1			2	
Heard Systems Pty Ltd								1	1	2		
Neuro Insight Pty Ltd						4						
Techmin Pty Ltd	1				3							
Franz Pty Ltd Burkhard			1							1	1	
Resonance Health Analysis Services Pty			1		1						1	
Sspt Pty Ltd			1		1	1						
Starpharma Pty Ltd					1	1					1	
Alivecor Inc										1	1	
Austin Health			1				1					
Brain Res Inst Pty Ltd					1					1		
Cuoretech Pty Ltd				1		1						
Daltray Pty Ltd			1	1								
Eye Diagnostics Pty Ltd				1		1						
Heart Assist Technologies Pty Ltd	1		1									
High Tech Health Int Ltd						2						
Nmr Holdings No 2 Pty Ltd						1			1			
Objectivision Ltd						1	1					
Sbc Res Pty Ltd						1			1			

Source: DWPI

Appendix R: Vision PCT filing activity, by priority year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Nat Ict Australia Ltd					1			2	8	1	10	
Newsouth Innovations Pty Ltd	1	2	1	3	1		2	1	2	1	4	
Bionics Inst		1	1			1	1	1	4	2	3	
Holden Vision Inst Brien		1	1			2	3	1	1	1	1	2
Lions Eye Inst	4	3	1	2					1			
Inst Eye Res		1	3			2	3	1				
Visioncrc Ltd			2			3	2	1		1		
Ellex R&D Pty Ltd	1	1		1		3	1			1		
Zeiss Vision Australia Holdings Ltd Carl	1				3	2						
Opto Global Holdings Pty Ltd					1	1	3					
Customvis Plc				2	1				1			
Cv Laser Pty Ltd				2	1				1			
Sola Int Holdings	1				2	1						
Cent Eye Res Australia									2		1	
Eye Diagnostics Pty Ltd				1		1						
Hoya Corp				1							1	
Novartis Ag	1	1										
Q-Vis Ltd	1	1										
Qirx Pty Ltd							1		1			
Seeing Machines Ltd								1	1			
Vision Instr Pty Ltd	1			1								
Advanced Ocular Systems Ltd						1						
Adventus Technology Inc											1	
Anew Optics Inc						1						
Clearlab Int Pte Ltd				1								
Clearmark Technologies Pty Ltd		1										
Clvr Pty Ltd		1										
Cooper Vision Inc			1									
Flinders Partners Pty Ltd			1									
Hogan Pty Ltd Martin			1									
Iatia Imaging Pty Ltd				1								
Ing Lytzen As				1								
Menicon Co Ltd				1								
Menicon Singapore Pte Ltd				1								
Microban Prod Co						1						
Ncode Pty Ltd				1								
Neuro Vision Technology Pty Ltd					1							
Ocular Biomed Pty Ltd								1				
Ocular Sci Inc			1									
Oculeve Inc											1	
Ophthalmic Eng Pty Ltd			1									
Oryx Holdings Pty Ltd					1							
Penglase Investments Pty Ltd	1											
Transcend Medical Inc			1									
Visiomed Group Ltd					1							
Warm Contact Pty Co Ltd											1	

Source: DWPI

Appendix S: Top six PCT applications that have been cited over 100 times

Publication number	Citing patent count	Applicants	Technology specialisation	Title of invention
WO2008000020	260	FERMISCAN AUSTRALIA PTY LTD; SBC RES PTY LTD	Cutting Edge/Other	Detecting method for abnormal component in keratin sample involves comparing data obtained from derived chemical substance with data contained in reference database to identify presence of abnormal component in keratin sample
WO2010000020	114	CATHRX LTD	Catheters	Catheter sheath for catheter assembly has bracing structure interposed between distal part of sleeve and portions of discrete elements to brace portions of discrete elements in their operative position
WO2002100267	107	COMPUMEDICS LTD	Electromedical/ Diagnostics; Measuring; Respiratory	Patient consciousness monitoring for automatically detecting and signaling transition states in consciousness, by analyzing electro-encephalogram (EEG) signals on basis of frequency and phase
WO2005087140	104	PERCUTANEOUS CARDIOVASCULAR SOLUTIONS PT	Stents	Percutaneous mitral valve prosthesis used for medical application, has anchor line extending between valve structure and anchor device which is collapsible during delivery with respect to catheter
WO2004098405	103	AIMEDICS PTY LTD	Electromedical/ Diagnostics; Measuring	Physiological condition monitoring device for e.g. hypoglycemia, has portable receiver that receives processed signal related to parameter being monitored, and displays data related to patient
WO2005063328	102	RESMED LTD	Emergency/Life Saving; Respiratory	Breathing arrangement for breathing of patient has oronasal interface that can be placed on patient's face covering patient's mouth through headgear assembly to supply breathable gas from inlet conduit to patient

Appendix T: Top six PCT applications with the highest cited patent families

Publication number	DPCI	Applicants	Technology specialisation	Title of invention
WO2002100267A1	155	COMPUMEDICS LTD	Electromedical/ Diagnostics; Measuring; Respiratory	Patient consciousness monitoring for automatically detecting and signaling transition states in consciousness, by analyzing electro-encephalogram (EEG) signals on basis of frequency and phase
WO2002100240A3	148	CARDIAC DIMENSIONS INC	Stents	Mitral valve therapy assembly has mitral valve annulus device slidingly received on guide wire and reshapes mitral valve annulus when in coronary sinus of heart
WO2002072870A3	144	FLINDERS TECHNOLOGIES PTY LTD; FLINDERS UNIV S AUS; WHATMAN INC	Other/Cutting Edge	Solid medium for storage of DNA, esp. blood DNA comprising solid matrix having cpd. or compsn. incorporated or absorbed to protect against degradation of DNA
WO2003034948A1	128	COOK AUSTRALIA PTY LTD WILLIAM A; COOK INC	Stents; Surgical	Flexible tubular prosthetic device for placement or in replacement of curved lumen, has control arrangement to control length of one side with respect to other side so that device can be curved in situ
WO2006135511A1	125	DEPUY SPINE INC	Surgical	Vertebrae stabilizing method for stabilizing and protecting posterior elements of the spine involves placing central spacer is placed by squeezing two of its arms together and passing the same arms between spinous processes
WO2002067797A2	111	ANGIODYNAMICS INC; RITA MEDICAL SYSTEMS INC	Surgical	Tissue surface treatment apparatus for ablative treatment, has cam unit connected to electrode assembly, for adjusting position of electrodes into target tissues independently

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