INTELLECTUAL PROPERTY OFFICE

3DTVs

A patent landscape analysis

Introduction

Consumer television has changed a lot over the last 50 years from black and white cathode tube TVs, to colour TVs, to LED high-definition TVs. In the last couple of years 3DTVs have hit the high street and after a slow and sceptical start demand is beginning to pick up; this is mainly due to live televised sports coverage such as Premier League football every weekend[1], the 2012 Wimbledon final[2], and over 200 hours of 3D coverage at the London 2012 Olympic Games[3].

Recent patenting activity suggests that television is still evolving - and at an ever-increasing rate. The latest TV screens are bigger, thinner, internet-enabled and more immersive than ever. High-definition may soon be a thing of the past as it is eclipsed by ultra-definition TV. In August 2012, LG launched the world's first 84-inch ultra-definition (UD) 3DTV in the Korean market[4] with 8 million pixels per frame and four times the resolution (3840×2160) of existing full HD 1080p screens.

This patent landscape report focuses on the rise of 3DTV from concept to high street and offers a glimpse of what you might expect to find in the corner of your living room in the next few years.

Background

The stereoscope was first invented in 1838 by Sir Charles Wheatstone who showed that when two pictures are viewed stereoscopically they are combined by the brain to produce 3D depth perception[5]. Stereoscopic 3D television was demonstrated by John Logie Baird for the first time[6] in 1928, and in 1935 the first 3D colour movie was produced. 3D movies were popular in the 1950s when TV became 'all the rage' in the USA, and IMAX 3D cinemas began producing 3D documentary films in the 1980s. In the mid-2000s 3D movies began to take off again with several big Hollywood movie studios backing the format, and in 2009 broadcasters announced that they would begin showing 3D programmes. The transfer of 3D video from cinemas into the home and the availability of 3D content for TV were landmarks in the history of 3D television. On 1 October 2010 Sky launched the UK's only dedicated 3D TV channel[7], Sky 3D, which shows a mixture of movies, entertainment and sport for 16 hours a day.

The 3D effect created by most 3DTVs results from a combination of a 3D display and 3D glasses working together. A 3D display generally offsets images independently to the viewer's left and right eyes so that the viewer perceives the image to have depth. Most 3DTVs have either passive or active 3D glasses. Many passive 3D glasses use polarised lenses with each lens polarised in opposite directions. Active 3D glasses use frame sequential display where images are split into a series of alternating frames for each eye that are displayed consecutively and rapidly so that the frames are processed quickly before the brain discovers flickers in the lenses. However, the most recent 3DTVs to hit the high street are full-3DTVs with glasses-free autostereoscopic displays, and these are marketed as "the future of television"[8].

1 http://www.skysports.com/story/0,19528,12942,00.html
2 http://www.bbc.co.uk/sport/0/tennis/18700322
3 http://www.panasonic.co.uk/html/en_GB/News/Latest+News/First+Live+3D+Olympic+Games+for+London+2012/8057482/index.html
4 http://www.lgnewsroom.com/newsroom/contents/62370
5 http://www.stereoscopy.com/library/wheatstone-paper1838.html
6 http://www.bairdtelevision.com/stereo.html
7 http://www.sky.com/3d
8 http://reviews.cnet.co.uk/tvs/toshiba-55zl2-review-50005001/

General patenting trends

A tailored search in the EPO and Thomson Reuters worldwide patent databases in August 2012 found over 50,000 published patent applications worldwide. This equates to approximately 30,000 different inventions (30,000 patent families[9]). The historical profile of published patent families in Figure 1 shows that there has been a sharp increase in 3DTV patenting in recent years; in 2011 almost 4000 patent families were published and, with almost 3500 already published up until August 2012, we predict that there will be approximately 5200 published patent families by the end of the year, which is a 350% increase over 2009.

The red granted region in Figure 1 shows how many of the patent families published in that year have at least one granted family member, for example 50% of the 1029 patent families published in 2004 have a granted patent, and 35% of the 1444 patent families in 2009 have so far had at least one patent granted. Due to the inherent delay between filing and grant, which can be several years depending on the patent office processing the application, the granted figures are incomplete from about 2007 onwards. The grant rate of the completed years since 2000 suggests that between 40% and 50% of all 3DTV patent families have at least one family member granted.

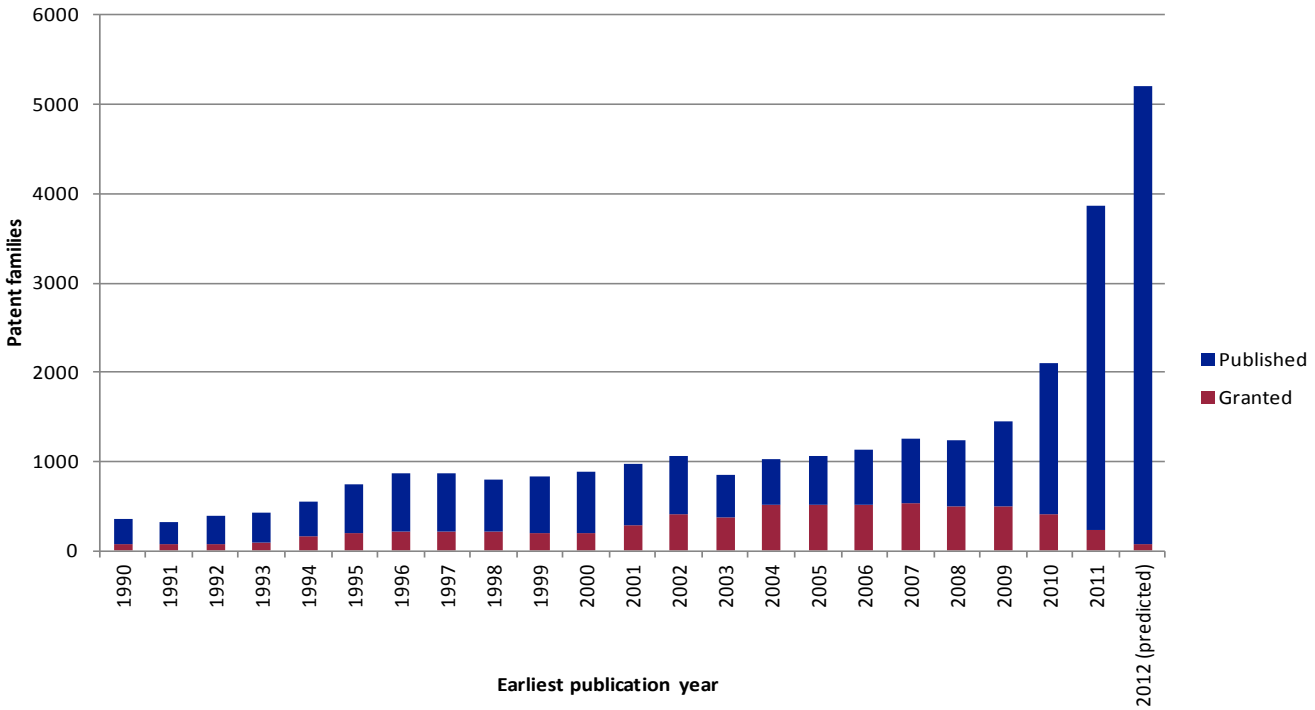

Figure 1: Historical patent family filing profile by earliest publication year

9 A patent family is defined as all documents directly or indirectly linked via a priority document. This provides an indication of the number of inventions an applicant may hold, as opposed to how many individual patent applications they might have filed in different countries for the same invention.

Sony has the largest portfolio of 3DTV patents with almost 1250 patent families (over 2500 published patents), although only 25% of these families have at least one patent granted. Samsung and Sharp are ranked 2nd and 3rd with just under 1000 and 800 patent families respectively, but Sharp have a 38% grant rate compared to 23% for Samsung. The list of top 15 applicants in Figure 2 is dominated by Japanese electronics giants with only three non-Japanese companies in the list; Samsung and LG (both South Korean) and Philips (Dutch). Less well-known companies that appear in the top applicants include NTT (Nippon Telegraph and Telephone), a Tokyo-based telecommunications company and NHK (Japan Broadcasting Corporation), the Japanese equivalent of the BBC that is funded by television licence fees.

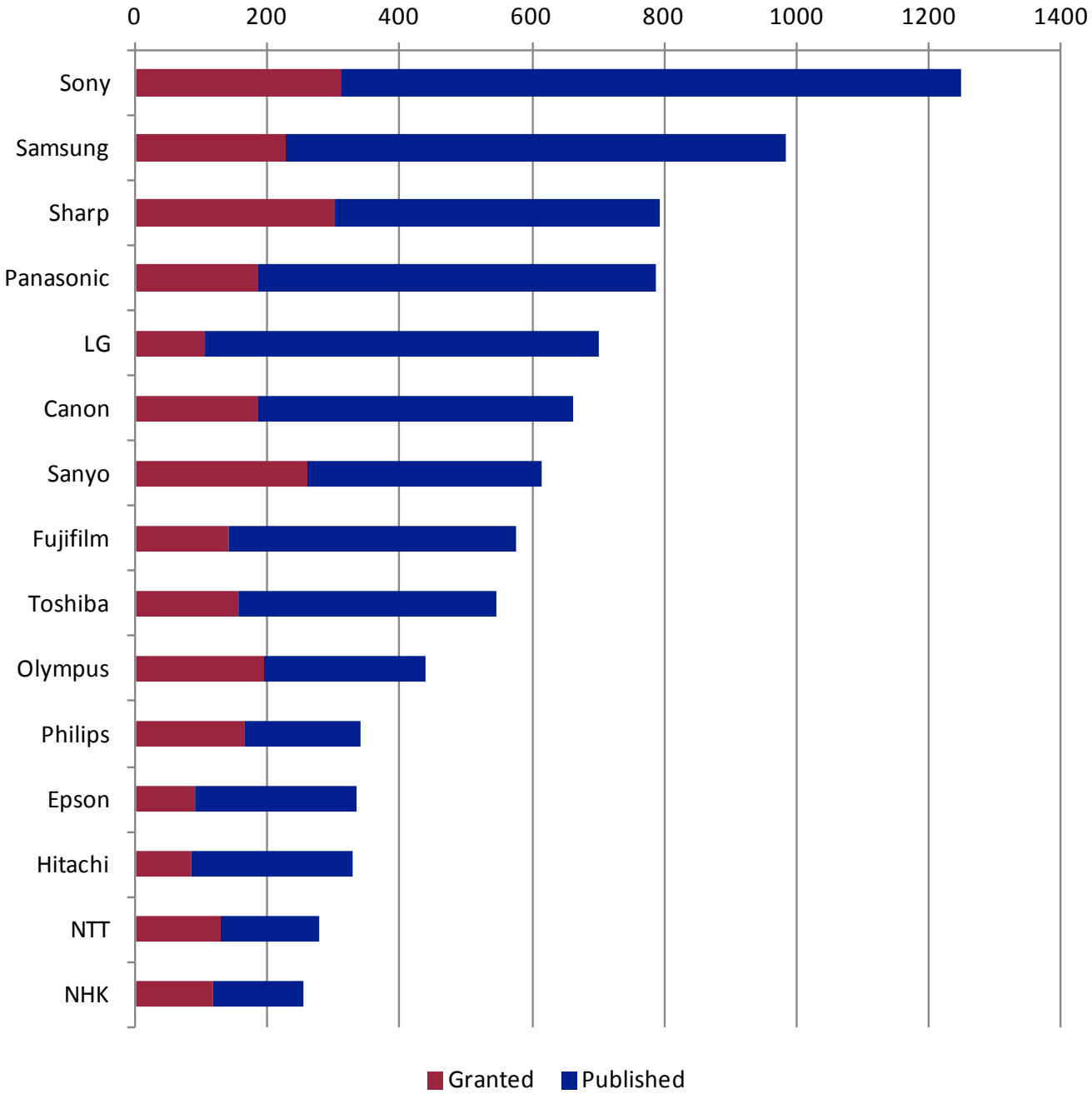

Figure 2: Number of published and granted patent families of the top applicants

The heat map in Figure 3 shows the patenting activity by priority year for the top 3DTV patentees. It is clear that the top five applicants have all significantly increased their 3DTV patent filings in the last few years whereas Sanyo filed heavily in the mid-1990s with very little activity in recent years. It is interesting to note that all of the top applicants with the exception of Sharp and Hitachi have filed over 80% of their 3DTV inventions since 1990; this suggests that Sharp and Hitachi have both spent time and money researching and developing 3DTV techniques for longer than the other key players with significant filings for both companies in the late-1980s. Consequently Sharp has a considerably higher grant rate than Samsung, as mentioned above in relation to Figure 2, because number of published and granted patent families of the top applicants2, because many of Samsung's applications are recent and may still be pending.

Figure 4 illustrates the collaborations made by the top two 3DTV patent applicants (Sony and Samsung) and their collaborators with each dot representing one patent family.

Sony has over 1200 patent families in their name only, but they have collaborated domestically in Japan with some of the other top applicants shown in Figure 2; Sony have collaborated with Epson on four inventions and jointly with Sharp and Sanyo on three inventions, and Sharp and Olympus on nine inventions. Sony's only international collaboration is with their own subsidiaries and they have a number of collaborations with their American (Sony Electronics Inc) and European (Sony Europe Ltd) subsidiaries.

Samsung have worked more collaboratively on 3DTV patents than Sony. They have worked with a number of other Korean companies and universities on a handful of different 3DTV inventions, and they have also worked with Bauman Moscow State Technical University in Russia and the University of Southern California in the USA.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sony	10	12	19	39	9	31	23	38	38	32	45	24	39	44	13	34	26	35	78	210	323
Samsung		1	1			3	8	8	10	4	8	7	11	14	40	71	53	116	118	185	292
LG		1	2		2	3		1	13	6	3	8	3	6	14	23	50	58	44	138	318
Panasonic	16	3	4	18	19	26	25	11	21	17	18	6	6	6	26	18	25	16	49	114	202
Canon	1	4	11	51	66	40	47	37	30	34	48	46	33	31	25	21	6	14	11	33	40
Sharp	1	6	10	19	13	20	33	20	7	7	4	2	73	87	38	41	23	6	16	35	144
Sanyo	4	4	10	43	133	87	44	64	16	26	11	38	28	43	9	14	5	2	2	5	7
Fujifilm	1	7	4	15	4	7	2	2	11	20	10	3	13	25	20	16	24	45	53	87	164
Toshiba	9	5	4	6	6	7	11	17	21	16	12	6	16	16	17	20	18	26	34	50	99
Olympus	4	7	20	21	30	44	13	5	7	12	23	56	28	30	35	18	15	8	10	9	20
Epson	6	6	1	5	2	4	2	4	2	2	3	12	4	6	17	55	28	51	37	28	49
Philips		1	1		1	4	9	4	9	6	8	18	12	33	21	47	25	27	32	32	16
Hitachi	5	6	9	5	13	9	9	14	5	10	5	4	2	3	17	20	7	14	12	19	63
NTT	10	6	9	7	10	3	4	7	17	24	15	13	20	22	5	20	13	4	7	4	9
NHK	12	2		7	9	17	6	4	12	7	22	26	6	17	6	6	10	9	11	8	11

Figure 3: Heat map timeline by priority year for top applicants

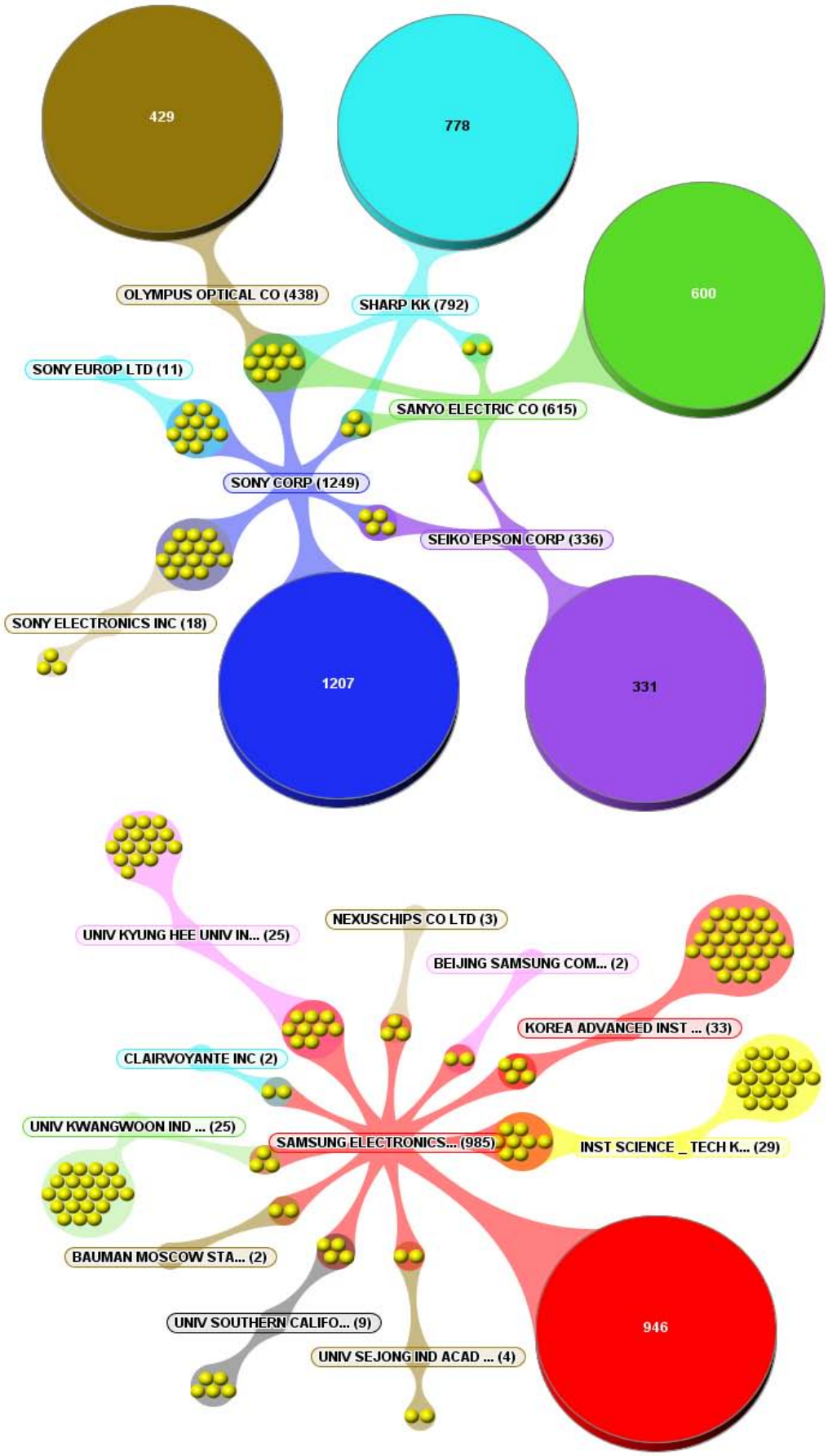

Figure 4: Collaboration map showing the collaborations made by the top two applicants and their collaborators

Given the dominance of multi-national corporations among the top applicants it is not surprising that when the list of 3DTV patent applicants is split by sector, as shown in Figure 5, the corporate sector dominates. New and emerging technology areas often have a significant contribution from academia, but in this case the basic technology has been around for many years and it appears that further technological advances are coming out of the R&D budgets of the global brands rather than stemming from academic research. The contribution from individual applicants is a little higher than expected because individual applicants are more likely to innovate in a technology that they use on a daily basis.

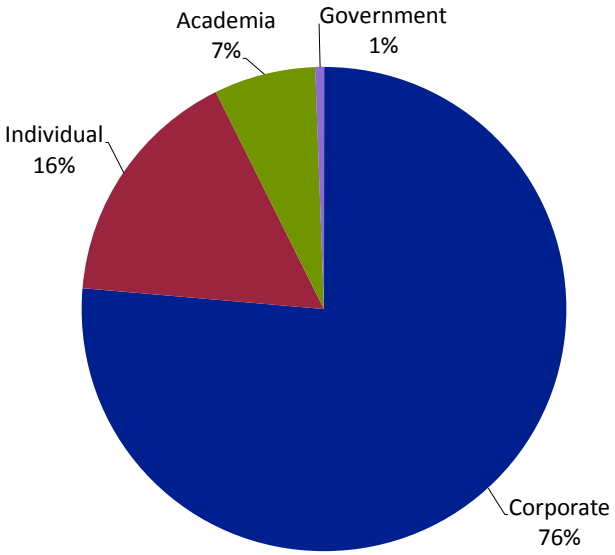

Figure 5: Sector breakdown

For many technology areas the USA and Japan have similar levels of patenting, but Figure 6 shows that Japanese applicants have over three times the number of patents compared to American applicants. However, this not that surprising given that most of the world's consumer electronics giants are based in Japan. The UK is ranked 8th worldwide at 2%.

However, it is well known that there is a greater propensity to patent in certain countries than others (in particular and as mentioned previously, American and Japanese inventors are prolific patentees across most technology areas), and the distribution shown in Figure 6 may change if the figures are corrected for this difference in behaviour. Therefore, the Relative Specialisation Index (RSI) for each applicant country has been calculated to give an indication of the level of patenting in the 3DTV sector for each country compared to the overall level of patenting in that country, and this is shown in Figure 7.

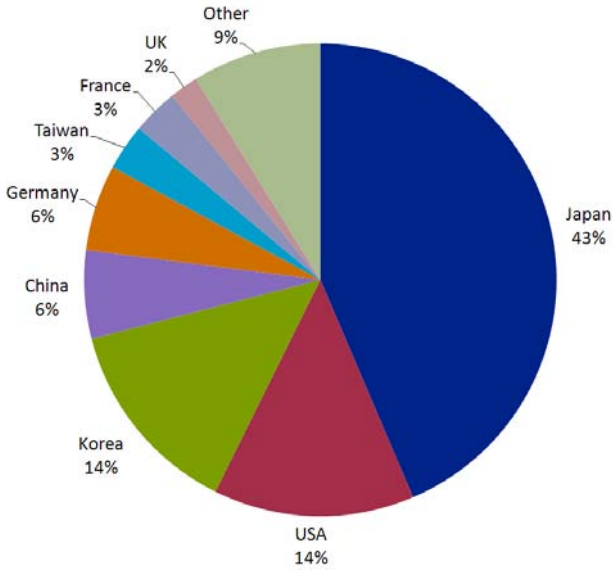

Figure 6: Applicant country distribution

RSI is 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. This RSI compares the fraction of 3DTV patents from each applicant country to the fraction of total patents from each applicant country and applies a logarithm to scale the fractions more suitably. The formula is given below:

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

where n_i = number of 3DTV patents in country i; n_{total} = total number of 3DTV patents in dataset; N_i = total number of patents in country i; and N_{total} = total number of patents in dataset.

The effect of this is to highlight countries which have a greater level of 3DTV patenting than expected given their overall level of patenting and which would otherwise languish, unnoticed, much further down the list of top applicant countries.

The RSI chart in Figure 7 suggests a different picture to that shown in Figure 6. Japan and Korea are ranked 4th and 7th and both have a positive RSI value which shows that in reality applicants from these countries file more 3DTV patents than would be expected given their overall levels of patenting; given the size of companies like Sony and Samsung in these countries this is not unexpected. However, the USA has a negative RSI value and is ranked 17th worldwide, below the UK in 15th, which means that American applicants file fewer 3DTV patents than expected given the overall level of patenting in the USA.

Along with Japanese and Korean applicants, applicants with the highest RSI scores come from Cyprus, Luxembourg, New Zealand and Israel; these high-ranking countries, especially Cyprus, show much greater levels of patenting in the 3DTV sector than expected given their modest absolute levels of patenting.

Cyprus, ranked 1st, has an RSI of 1.3 which is over double the score of Luxembourg who are ranked 2nd; this is all due to one company, Xpand Ltd, who have their headquarters in Cyprus and who have 94 of the 95 published 3DTV patents from Cyprus applicants. Based on the content of these patent applications, it appears that Xpand[10] specialise in 3DTV active shutter glasses, including the use of OLED shutter glasses and the communication protocols used to operate the shutter glasses with the display device.

Similarly, the high scores from Luxembourg and New Zealand are due to one major 3DTV applicant in each country; SeeReal Technologies[11], who have filed patents relating to autostereoscopic multi-user displays and holographic 3D displays, have 145 of the 173 3DTV patents from applicants from Luxembourg, and PureDepth (formerly Deep Video Imaging) specialise in 3D displays[12] and account for 91 of the 128 3DTV patents from applicants from New Zealand.

3DTV patents from UK applicants are around the level expected given the overall level of patenting from UK applicants (with a mildly negative RSI score of -0.12) but the UK is not a world-leading specialist in the 3DTV sector.

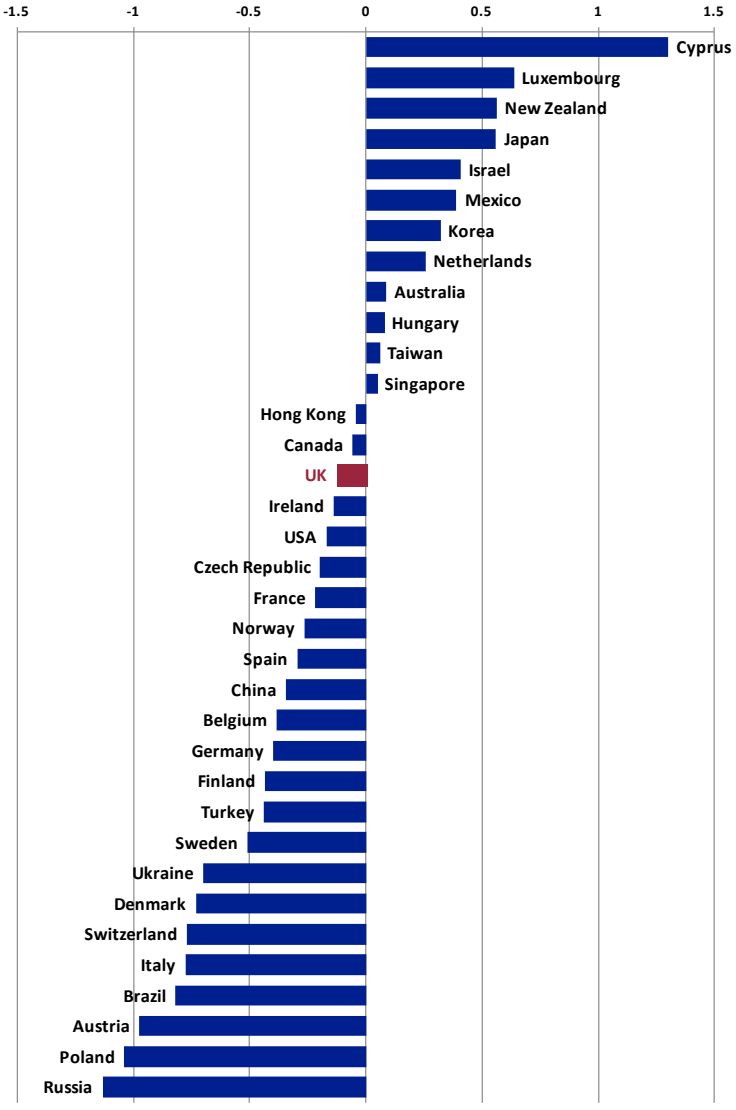

Figure 7: Relative Specialisation Index (RSI) by applicant country

10 http://www.xpand.me/

11 http://www.seereal.com/

12 http://www.puredepth.com/

The technology landscape

In order to visualise what the 3DTV patent landscape looks like, a patent map provides a representation of the dataset. Patents are represented on a patent map by dots and the more intense the concentration of patents (i.e. the more closely related they are) the higher the topography as shown by contour lines; this results in 'snow-capped peaks' in areas with lots of related patents and areas of 'sea' where there are very few related patents. The patents are grouped according to the occurrence of keywords in the title and abstract and examples of the reoccurring keywords appear on the patent map.

Figure 8 shows the 3DTV patent landscape and several key areas within this technology space are highlighted for clarity. The patent map covers all 3DTV patents, ranging from stereoscopic image capture and camera calibration through to 3D glasses design and display technologies.

Figure 8: 3DTV patent landscape map

Autostereoscopic 3DTVs (3DTVs without glasses) are expected to be the next major breakthrough in this sector but patents relating to autostereoscopic technologies (less than 4% of all 3DTV patents refer to autostereoscopy) are not well defined (clustered together) on the patent map. This is due to the nature of the technology because autostereoscopic displays are generally either based on a complex lens design such as a lenticular lens, or a complex parallax barrier arrangement. Other challenges that face autostereoscopic 3DTVs include viewer movement and multiple viewers; existing autostereoscopic displays such as the one used on the Nintendo 3DS® handheld games console is a single-view display with a clearly defined 'sweetspot' in which the viewer's head needs to be positioned to get the best 3D effect. In a family living room, an autostereoscopic 3DTV needs to cope with multiple viewers who may move or have their heads at different angles. These are the challenges facing the TV industry and many patents detail different methods and techniques of trying to overcome these challenges, such as moveable parallax barriers and head/eye tracking (see Figure 9). The diversity of technologies that go into an autostereoscopic 3DTV explains why related patents are spread across the 3DTV patent map, although small clusters of autostereoscopic patents are located in the areas labelled 'lens design' and 'parallax barrier displays'. A small cluster is also located around the small 'peak' at the top centre of the map labelled with the keywords 'pixel', 'direction' and 'arranging', which contains patents relating to sub-pixel layout and displaying a autostereoscopic image with multiple viewpoints. Some autostereoscopic 3DTVs are already available on the high street, but affordable systems for the home are expected in the next year[13].

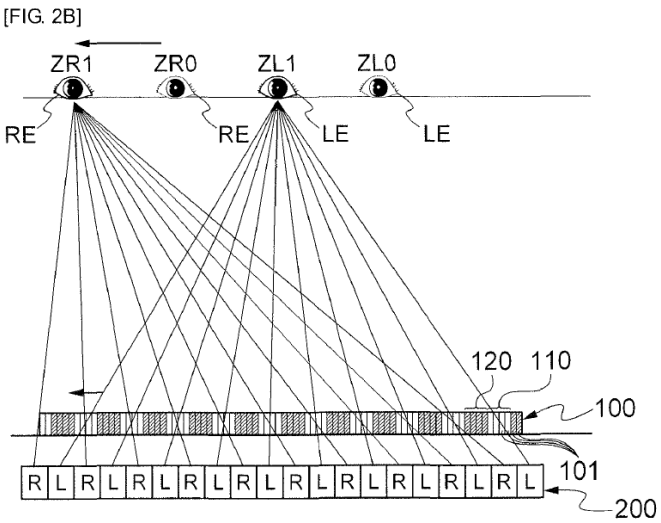

Figure 9: Drawing taken from GB2487997 (Samsung) showing a viewer-tracked autostereoscopic 3D display with a dynamic electrically-controlled parallax barrier

13 http://www.3dfocus.co.uk/3d-news-2/affordable-glasses-free-3d-tv-for-the-home-by-end-of-2012/9944

However, the biggest game-changer in the 3DTV market could be holographic TV (holo-TV). Holographic TV has been anticipated for decades, ever since the days of R2-D2® projecting a hologram of Princess Leia crying out for help in Star Wars®, but the cutting edge of research means that it is potentially closer to reality than many people realise. It is expected to change how we entertain ourselves at home, watch sport, and even how we communicate with each other[14].

There is a peak in the lower-right hand corner of the patent map labelled with the keywords 'hologram', 'light' and 'holographic' and this contains over 300 patents relating to holographic displays. For the last few years the problem hampering the development of holographic TV has been the inability to make holograms with refresh rates quick enough to convey movement. This has now been overcome with new laser technology and new screen technology[15]; 16 cameras are used to focus on a single object and the images are sent via Ethernet to a computer which reconstructs them into a 3D holographic image. The computer sends this information to a laser which shoots holographic pixels onto a photorefractive polymer material (plastic screen) that reacts to the laser and stores the image. It is widely speculated[15,16] that holographic TVs could hit the high street in the next few years and the Japanese TV network NHK have promised to have this technology in homes by 2016. Holographic TV also formed part of Japan's bid to host the 2022 football World Cup[16].

14 http://holo-tv.com/

15 http://www.pcworld.com/article/209772/holographic_tv_coming_your_way_in_2017.html

16 http://www.telegraph.co.uk/technology/news/9492054/Holographic-X-Factor-Welcome-to-the-future-of-television.html

3DTV patenting in the UK

3DTV patent applications at the IPO also show a general increase over recent years, but not at the same level as seen in the worldwide profile shown in Figure 1. Figure 10 shows a higher percentage grant rate at the IPO compared to the worldwide data, with 60-75% of all 3DTV patent applications granted in the UK.

Sharp is the leading 3DTV applicant at the IPO and they have a substantial 3DTV R&D team at Sharp Laboratories of Europe (based in Oxford), who have been one of the leading researchers in 3DTV since the laboratories were founded in 1990. 3DTV patenting in the UK is as diverse as it is worldwide, and includes patent applications relating to the automatic switching of a TV from a 2D mode to a 3D mode depending on if the viewer is wearing 3D glasses (GB2480999, Sony), parallax barrier autostereoscopic displays with user viewpoint tracking (GB2317771, Samsung), multiplexed broadcasting of multiview stereoscopic TV through a monoscopic TV channel (GB2470402, BBC), and producing a 3D image from a single 2D image captured using a single lens camera (GB2486878, STMicroelectronics).

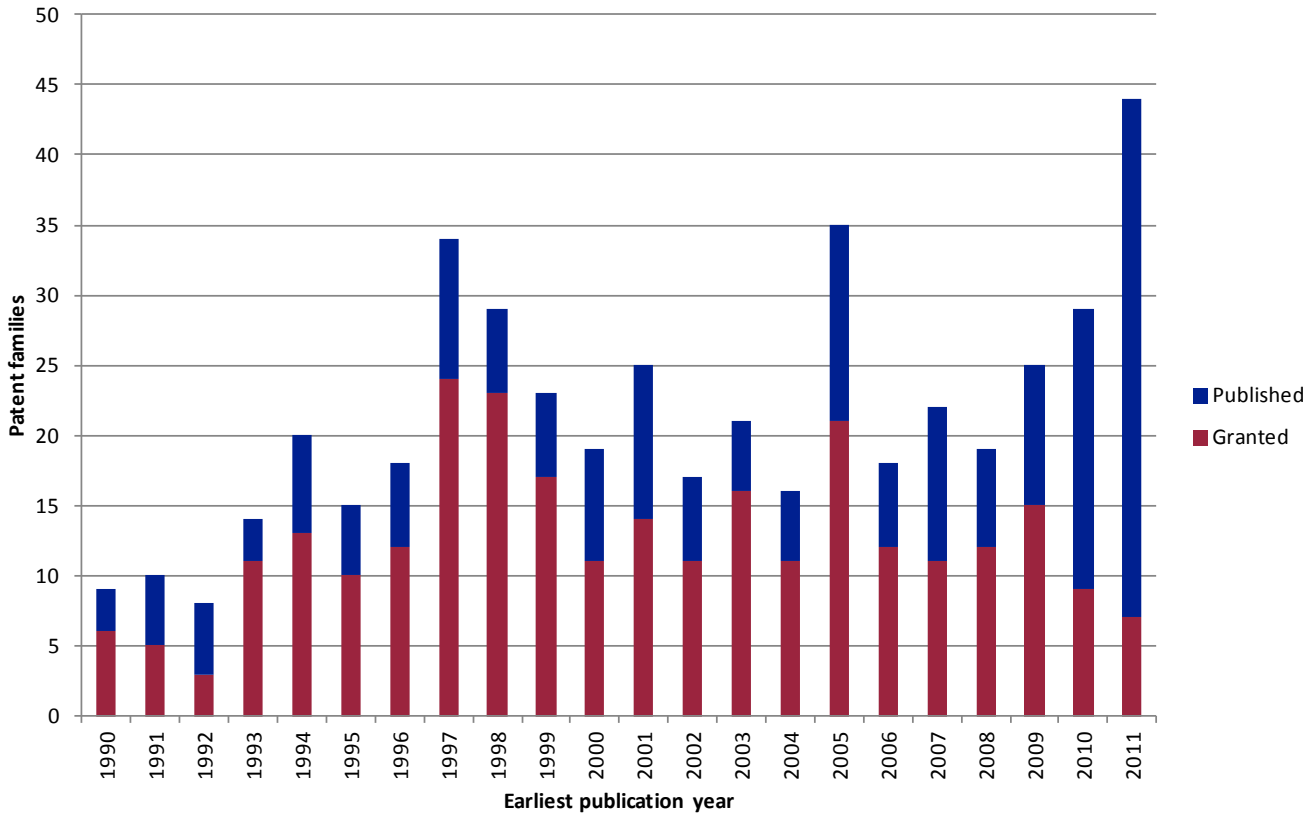

Figure 10: Historical patent family filing profile by earliest publication year for UK patent applications

Recent patenting activity

In the last three years there has been a rapid increase in the number of 3DTV patents worldwide, as clearly shown in Figure 2. This coincides with 3DTVs hitting the high street, the introduction of 3DTV broadcasting, and the success of major 3D Hollywood movies such as Avatar. This is not surprising because it is common for a surge in worldwide patent applications following the introduction of a disruptive technology into the marketplace; for example, a similar sharp increase in patent filings was seen in the razor market following the success of the first three-bladed razor, the Gillette Mach 3®, when it was launched in 1998.

The top 3DTV applicants since 2010 are shown in Figure 11 with the change in ranking between the data in Figure 2 (shown in brackets). Sony and Samsung are still ranked 1st and 2nd respectively, but LG have risen from 5th to 3rd meaning that two of the top three applicants are Korean. Fujifilm's rise from 10th to 5th is not surprising given the data shown in the heat map in Figure 3. Figure 11 suggests that the domination by Japanese companies evident in Figure 2 may be decreasing as new high filers from other countries are beginning to innovate more in the 3DTV sector; only 8 of the top 15 applicants since 2010 are Japanese compared to 13 of the top 15 in Figure 2. One of these new high filers is ETRI (Electronics and Telecommunications Research Institute, Korea), a government-backed research institute, and another is French firm Technicolor (formerly Thomson).

Since 2010 the corporate sector has dominated the 3DTV patenting activity even more with 84% of all 3DTV patents compared to 76% overall (Figure 5). The share of applications from academia has remained similar, but the share of applications from individuals has dropped in recent years from 16% to 8%, perhaps a sign that modern 3DTV systems, such as autostereoscopic 3DTVs, are more technically complex than older systems.

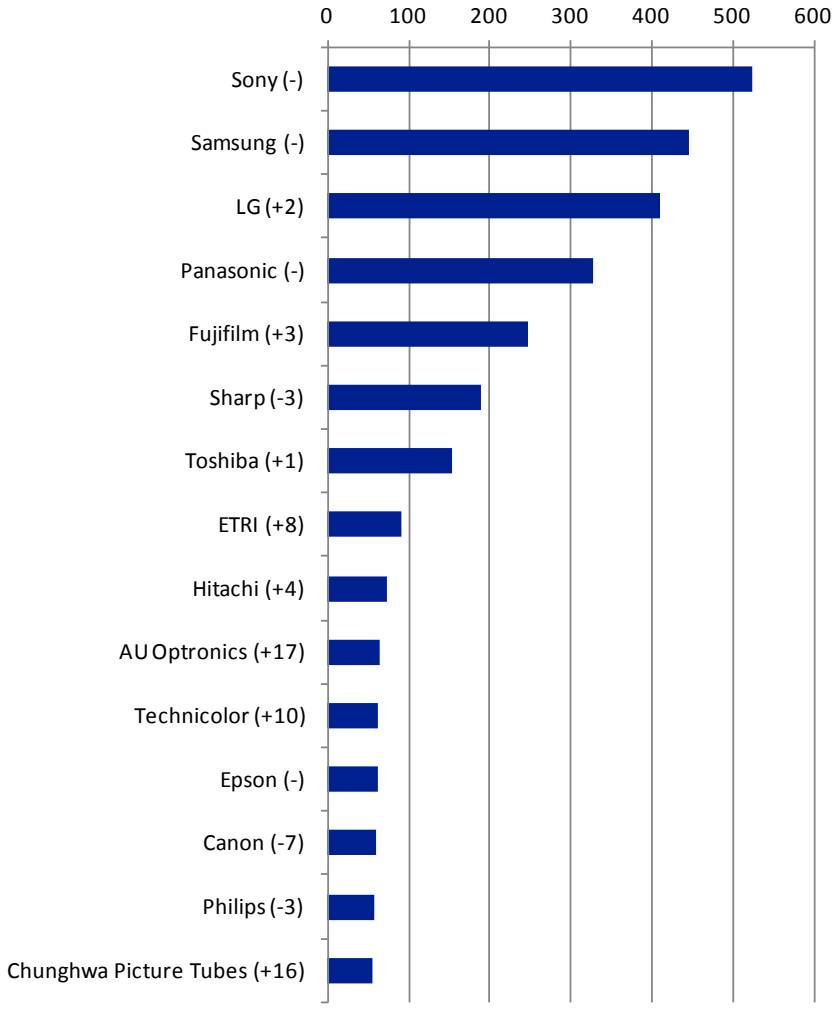

Figure 11: Top applicants since 2010

Figure 12 shows that the Japanese lead has decreased in recent years when compared with Figure 6. Japan's share of 3DTV inventions has dropped from 43% to 38%, but the big riser is Korea whose share is 23% since 2010, compared to 14% overall. This is expected given that three of the top 15 applicants shown in Figure 11 are Korean (Samsung, LG and ETRI).

Patent citation tracking is an interesting measure to analyse which patents are cited the most by patent examiners in their search reports when they process patent applications. The most cited patents are often seminal patents within that technology area. Since 2010 two Japanese patents have been cited the most by patent examiners; JP 2004274125 A (Sony) and JP 11191895 A (Panasonic).

JP 2004274125 A (Sony)[17] was published in 2004, but has a priority date in 2003, and relates to "displaying a title in an appropriate position", i.e. displaying a title or subtitles on a 3D display device so that the superimposed characters maintain a predetermined distance of perceived depth from the viewer.

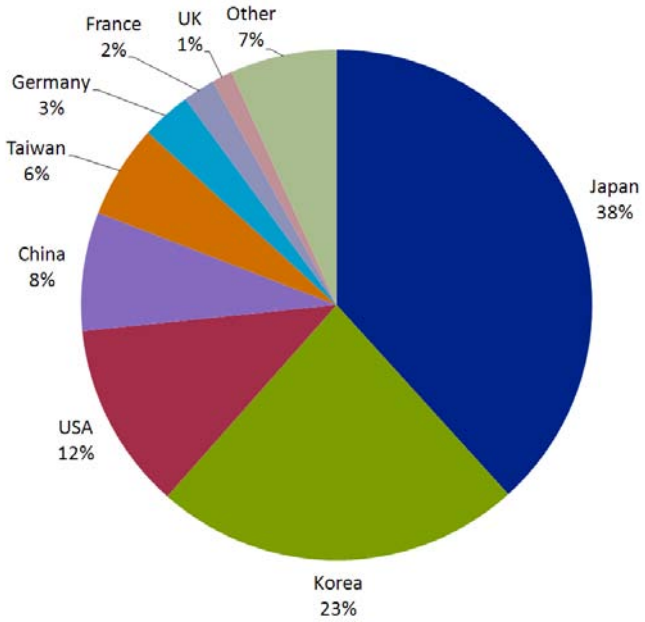

Figure 12: Applicant country breakdown since 2010

JP 11191895 A (Panasonic)[18] was published in 1999 but has a priority date in 1996, and relates to method of recording stereoscopic video content by dividing the video into frame groups and mutually interleaving and recording them on an optical disc.

Figure 13 shows the same 3DTV patent landscape map shown in Figure 8, but with the colour-coded dots highlighting the recent patents. Patents published between 2000 and 2009 are coloured blue, and the patents published since 2010 are coloured red. There are some clear differences between the blue and red dots shown in Figure 13; between 2000 and 2009 there are a lot of published patents in the bottom-left and top-centre parts of the patent map (general stereoscopic display design, stereoscopic image capture and calibration) but there have been relatively few in these areas since 2010. The absolute number of patents on the middle-right part of the map (polarised glasses and polarised displays) are similar when the two date ranges are compared side-by-side, but there is a clear increase in recent patents in the top-left and bottom-right parts of the graph.

The area in the top-left of the map comprises patents relating to shutter glasses design and control and many of these patents come from Sony, Samsung and Panasonic. Since 3DTVs became commonplace on the high street there has been a lot of media coverage regarding medical side effects created by 3DTVs. There are primarily two effects of 3DTV that are unnatural for human vision: crosstalk between the eyes, caused by imperfect image separation, and the mismatch between convergence and accommodation, caused by the difference an object's perceived position in front of or behind the screen and the real origin of that light on the screen. Some viewers have complained of headaches and eyestrain when watching 3DTV and it is believed that up to 12% of people are unable to properly see 3D images[19]. Figure 13 shows that the electronics giants take this issue seriously and there has been a rise in the number of recent patent applications aimed at trying to minimise these problems which could otherwise become a barrier to mainstream 3DTV market domination.

The area in the bottom-right of the map comprises patents relating to recording and reproducing stereoscopic video, with many of these patents coming from Sony and Panasonic. It is not surprising to see lots of Sony patents in this area because the Sony Blu-Ray® disc won the high-definition movie disc battle over Toshiba's HD-DVD® and has now been adopted as the industry standard optical disc for high-definition and 3D movies.

17 http://worldwide.espacenet.com/publicationDetails/biblio?DB=EPODOC&II=2&ND=3&adjacent=true&locale=en_EP&FT=D&date=20040930&CC=JP&NR=2004274125A&KC=A

18 http://worldwide.espacenet.com/publicationDetails/biblio?DB=EPODOC&II=0&ND=3&adjacent=true&locale=en_EP&FT=D&date=19990713&CC=JP&NR=11191895A&KC=A

19 http://www.telegraph.co.uk/technology/news/7887422/Six-million-Britons-cant-see-3D-TV.html

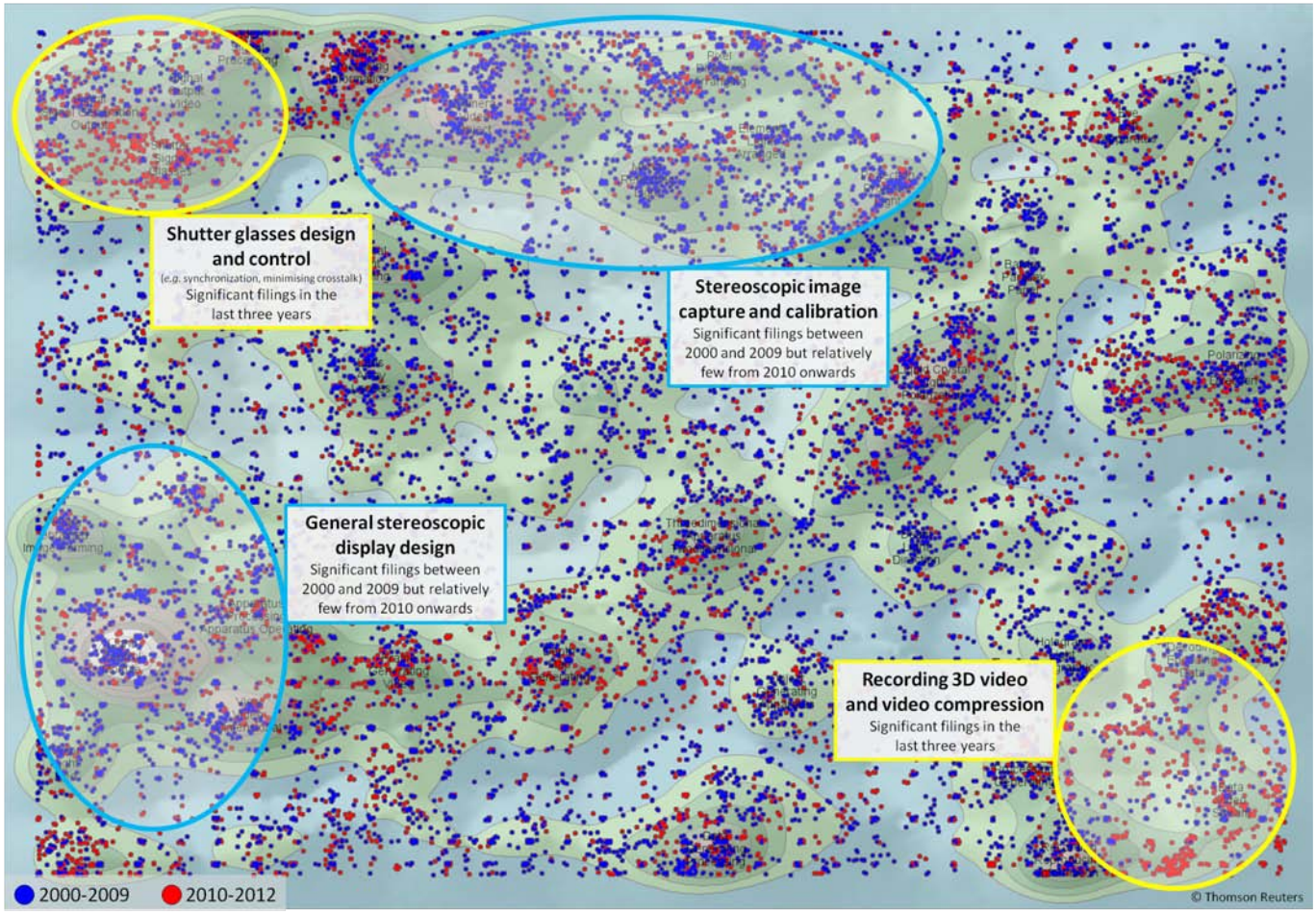

Figure 13: Time-sliced 3DTV patent landscape map

Conclusion

TV technology is moving on at a rapid pace and it is predicted that by 2014 close to half of all UK households will own a 3DTV[20]. However, most consumers will end up owning one by default as it becomes a standard feature on all new TVs. In the UK only Sky offer a dedicated 3D channel, but it is one channel out of over 400. When Sky launched their HD service in 2006 they only had 9 HD channels but that has now risen to 55 HD channels[21], so perhaps a similar increase will be seen for the broadcasting of 3D channels over the next few years. This lack of 3D content has so far been the stumbling block for the industry with the BBC reporting that only 66,000 people watched Usain Bolt win the London 2012 Olympic Games 100m final in 3D despite the fact that it was available free to air and with over 1m UK homes now owing a 3DTV[22].

The patent data shows that all of the major consumer electronic brands are investing heavily in 3DTV R&D with an 83% increase in published patent families between 2010 and 2011. We predict that by the end of this year the increase in published patent families between 2009 and 2012 will be over 350%. However, despite the recent surge in 3DTV patents, the success of 3DTVs and their impact on the viewing habits of households worldwide is more likely to be decided on the quantity and quality of the 3D content broadcast as well as a change of consumer attitude from 3DTV being a "gimmick" to a truly immersive viewing experience.

20 http://www.tvbeurope.com/newsletter-3dmasters-content/full/surge-in-3dtv-sales-attributed-to-unwitting-customers

21 http://www.sky.com/hd

22 http://www.3dfocus.co.uk/3d-news-2/3d-broadcasting/3d-growth-stalls-as-broadcasters-dig-in-for-the-long-haul/10156

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