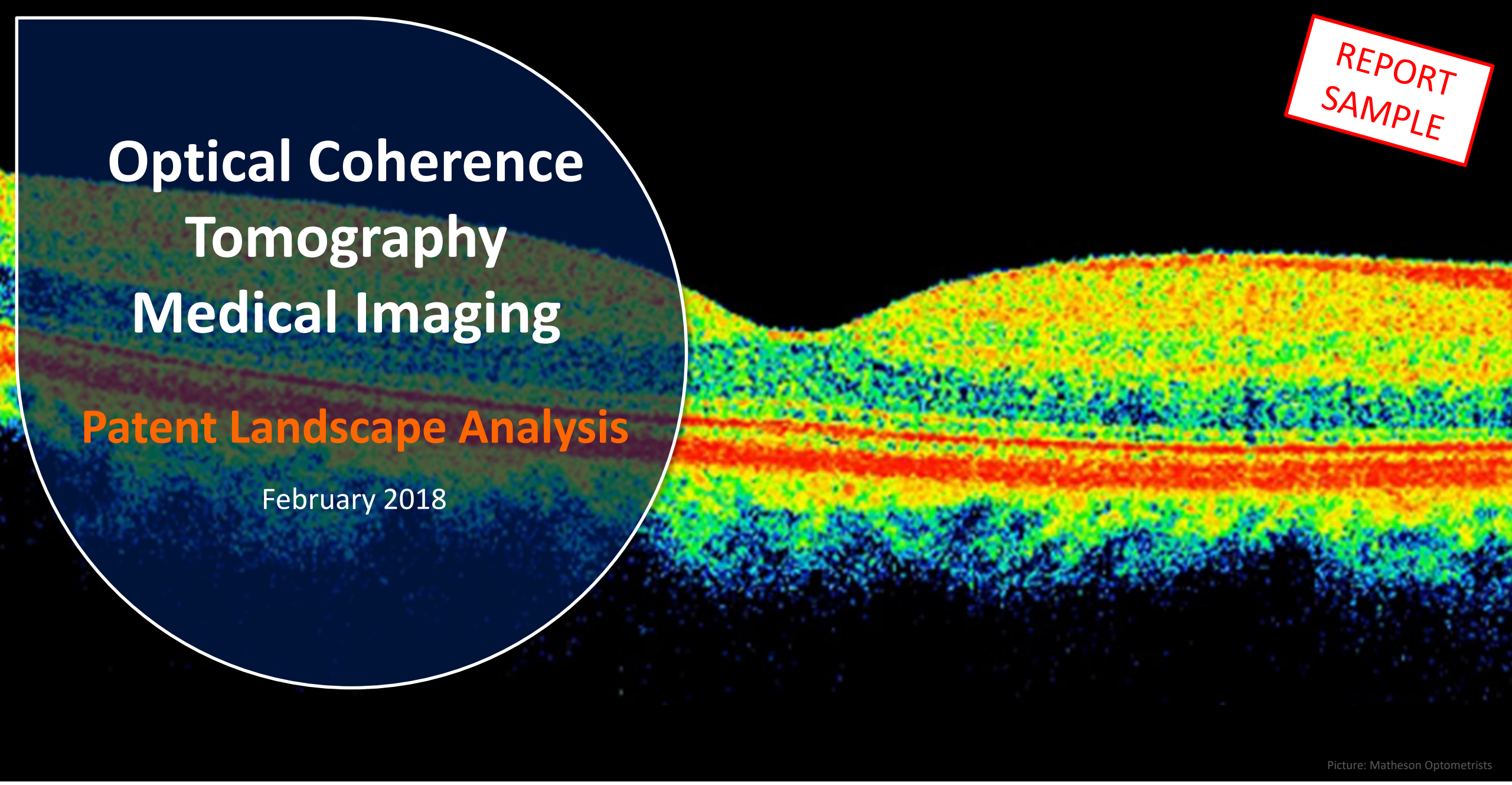
Optical Coherence Tomography Medical Imaging

Patent Landscape Analysis

February 2018

REPORT SAMPLE



Picture: Matheson Optometrists

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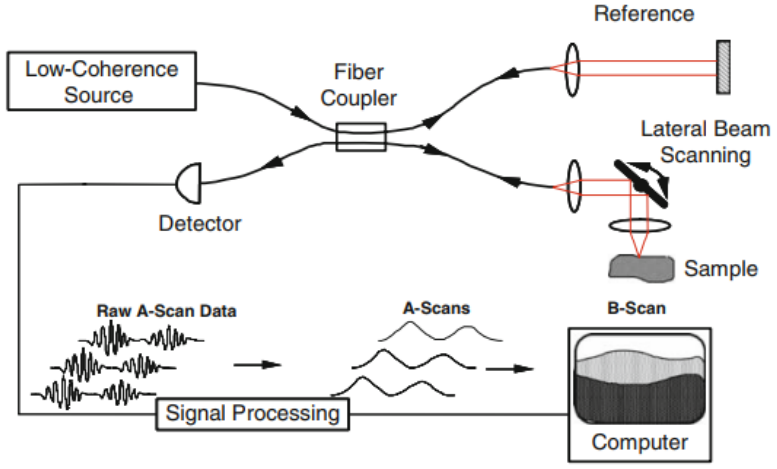
INTRODUCTION

Optical Coherence Tomography

Optical Coherence Tomography (OCT) is a non-invasive imaging technique widespread in the medical world, especially in ophthalmology. Its development started 25 years ago, under the impetus of the MIT. Since then, OCT imaging technology and capabilities have greatly evolved. The analysis of the IP landscape for OCT medical imaging shows that technical developments of OCT continue and expand its applicability.

OCT is analogous to ultra-sound technique, the difference being OCT measures light instead of acoustic waves. **OCT is based on low-coherence interferometry**, using a broadband light source, typically in the near-infrared domain. The echo delay and the intensity of the light backscattered from the sample are measured. Because of light travel speed, an optical correlation (also known as Michelson low coherence interferometry) is applied to perform the measurements. Technically, a basic OCT system includes 2 arms (see figure below). The light emitted by the light source is divided by a beam splitter: one beam is directed towards the sample (sample arm), and one beam is directed to a reference mirror (reference arm). The light backscattered or reflected from the sample is returned to a detector and combined with the light coming from the reference arm. When the distance between the light source and the sample is the same as between the light source and the reference mirror, it produces an interference pattern. OCT provides 3D images with a penetration depth of one millimeter and a lateral resolution of 10 micrometers. These capabilities place OCT between ultra-sound and confocal microscopy. Different light sources can be used for OCT imaging: superluminescent diodes (SLD), femtosecond lasers, and supercontinuum lasers.

OCT is a powerful medical imaging technique. It produces high resolution images at high speed and can be performed in real time. Its 1st application was ophthalmology for retina observation. Nowadays, OCT is routinely used for eye and retina examination. It can also be used during eye surgery. OCT has also been successfully adopted for vascular/cardiovascular imaging. For instance, it is integrated into intravascular catheters. For these applications, OCT is facing the competition of the well established ultrasound techniques. OCT is currently more expensive than ultrasound, but it offers a better resolution (OCT 10 microns, IVUS 100 microns). Both techniques can be combined to offer a multimodal imaging system. As OCT systems can be miniaturized, it can easily fit into small endoscopic systems. Considering the great impact this technology has had on the diagnostic and monitoring of diseases in ophthalmology and in the cardiovascular domain, developments are made to expand the technique to other medical applications, such as gastroenterology, dermatology, or gynecology.

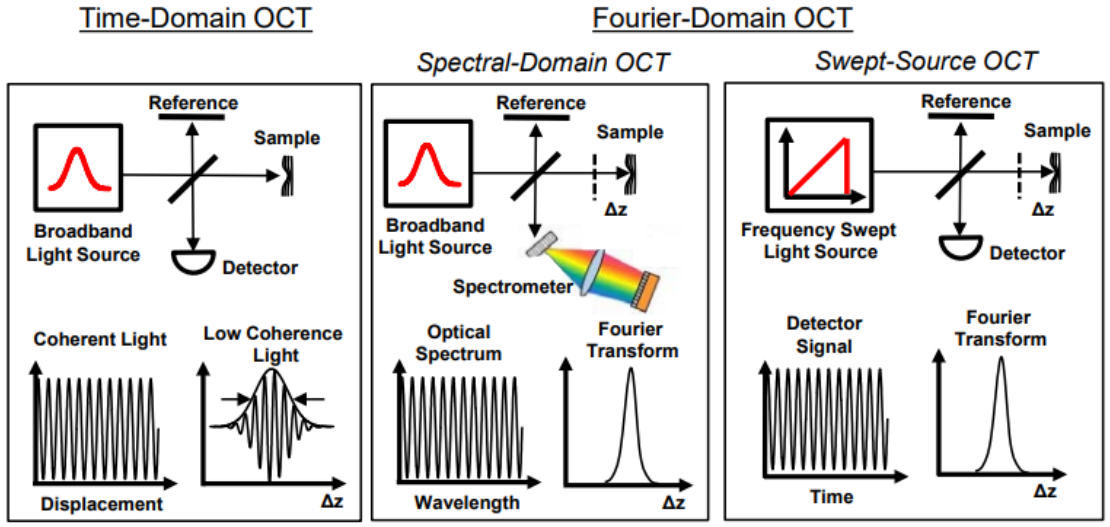


Basic OCT system (from Drexler & Fujimoto 2008)

INTRODUCTION
Optical Coherence Tomography

Different modalities of OCT have been developed over time (see figure below):

- **Time domain OCT (TD-OCT):** TD-OCT is the technique firstly developed. It uses a broadband light source and a reference mirror which is scanned accordingly to the sample (the path length of the reference arm is varied in time). Each scan of the mirror corresponds to the imaging of one layer of the sample.
- **Fourier domain OCT (FD-OCT):** in FD-OCT, the reference mirror is kept stationary, which allows a faster acquisition than TD-OCT. As the signals from all the sample layers are detected simultaneously, the signal-to-noise ratio is also improved. The distance between the light source and the mirror is approximately the same as the distance between the light source and the sample. FD-OCT can be performed according to 2 modalities depending on the light source and the detector:
    - **Spectral domain OCT (SD-OCT):** SD-OCT uses a broadband light source and the detector is combined with a spectrometer. The optical spectrum recovered is then analyzed using an inverse Fourier transform.
    - **Swept source OCT (SS-OCT):** SS-OCT differs from TD and SD-OCT by the nature of the light source. Here, a tunable laser is rapidly swept in wavelength. The spectral interference pattern is detected by a simple detector (such as used for TD-OCT).



The different OCT modalities (from Swanson & Fujimoto 2017)

INTRODUCTION

Optical Coherence Tomography

History of OCT in medical imaging

1991 — **1st OCT publication**[1] (*ex vivo* retina and coronary artery imaging)

1993 — **1st publications of *in vivo* OCT images** of the human retina[2,3]

1995 — Introduction of **FD-OCT** technology

1996 — **1st ophthalmic OCT product**

ZEISS

Zeiss' OCT1

1999 — **Ultra-high resolution OCT**: SLD replaced by femtosecond laser as light source (later: multiplexed SLDs)

2002 — Demonstration of speed and sensitivity advantages of **FD-OCT in retinal imaging**[4]

2004 — **1st cardiovascular OCT product** (intravascular imaging)

LightLab™ Optical Coherence Tomography

ST. JUDE MEDICAL

LightLab/St Jude's M2 imaging system and image-wire catheter

2006 — Several manufacturers introduce **FD-OCT products**

bioptigen · ZEISS · HEIDELBERG ENGINEERING · OPKO · OPTOPOL technology · OPTOVUE · TOPCON

2010 — **1st dermatology OCT product**

Michelson DIAGNOSTICS

Michelson Diagnostics' VivoSight

2013 — **1st gastroenterology OCT product** (esophageal endoscope)

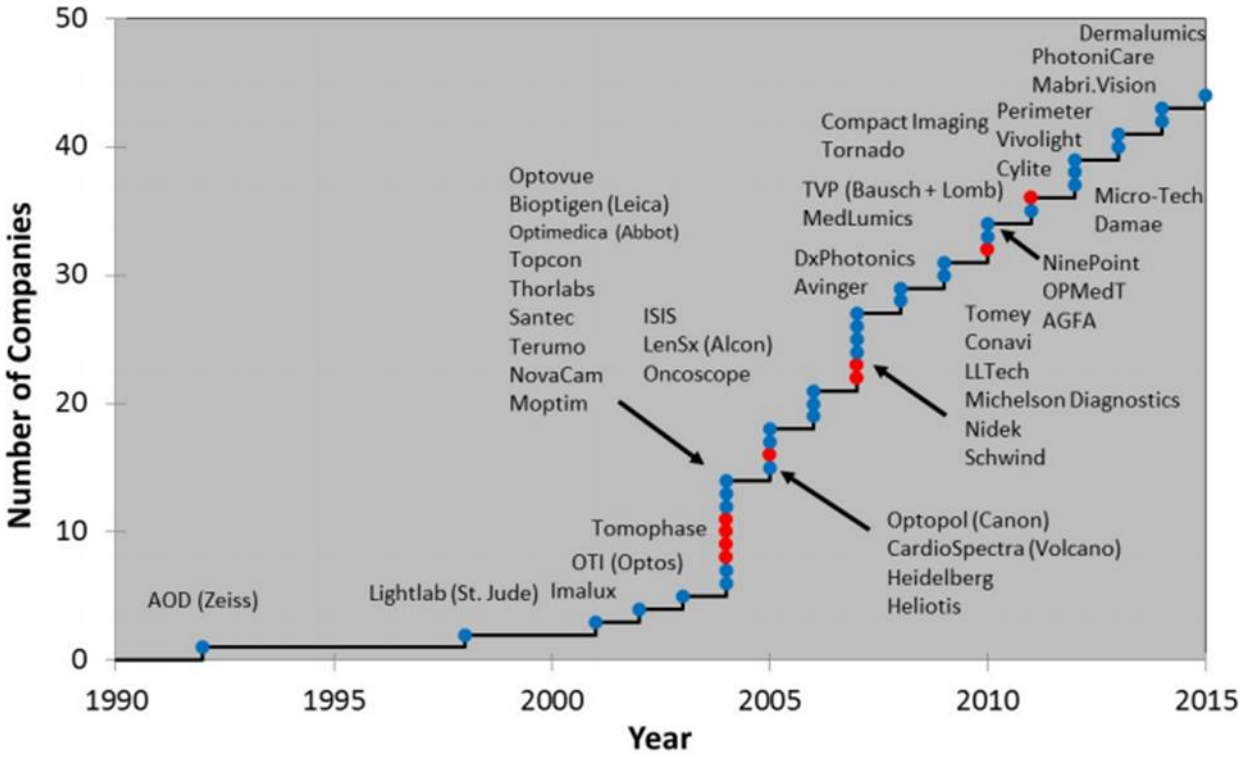
NinePoint MEDICAL

NinePoint Medical's NvisionVLE

1. Huang and Swanson, Science 1991
2. Swanson, Izatt, Hee *et al.*, Opt Lett. 1993
3. Fercher, Hitzenberger, Drexler, Kamp, Sattmann, Am J Ophthalmol. 1993
4. Wojtkowski, Leitgeb, Kowalczyk, Bajraszewski, Fetcher, J Biomed Opt., 2002

INTRODUCTION
Optical Coherence Tomography

Companies developing OCT systems over time
(from Swanson and Fujimoto[1])



Red dots: existing companies that started OCT internally
Blue dots: companies that began or still are startups
A few of these companies have been acquired or gone out of business

In parallel of the numerous developments in OCT, many companies have invested in this technology. The pioneers were **A**... (Advanced Ophthalmic Devices) and **LightLab Imaging** in the 1990s.
In 1992, **AOD** was the 1st OCT startup; the company was a spin off from **MIT and Tufts University** and was focusing on ophthalmology. Two years later **AOD** was acquired by **Zeiss**.
LightLab was born from a collaboration between the **MIT and Harvard**. **LightLab** was dedicated to cardiology. **LightLab** was acquired by **St Jude Medical** in 2009.
After FD-OCT was brought into focus as a promising technique in 2002, we observed an exponential increase of the number of companies in the OCT imaging market.
Nowadays, OCT systems and components are supplied by hundreds of companies and the number of OCT procedures performed each year is estimated at 30 million[1].
In September 2017, Accuray Research predicts that the global OCT market will continue to grow at 10.7% CAGR over the next decade[2]. According to this report, **the OCT market should reach around $2.2 billion by 2025**.
Implementations for OCT imaging in ophthalmology are continuously made and OCT imaging for other applications (cardiovascular, dermatology, oncology, etc.) are also in development. Many M&A also happened in the last few years. **In this context, the analysis the IP landscape for OCT medical imaging will allow to identify the IP players in a position of strength, their technologies in development and their targeted applications.**

1. Swanson and Fujimoto, Biomedical Optics Express 2017
2. Accuray Research LLC, Global Optical Coherence Tomography Market Analysis & Trends – Industry Forecast to 2025, September 2017

INTRODUCTION
Scope of the Report

- This report provides a detailed picture of the patent landscape for **optical coherence tomography for medical imaging.**
- This report covers **patents published worldwide up to October 2017**.
- We have selected and analyzed more than **4,850 patent families** relevant to the scope of this report.

Included in the report

✓ Patents related to OCT technology for **biomedical imaging**

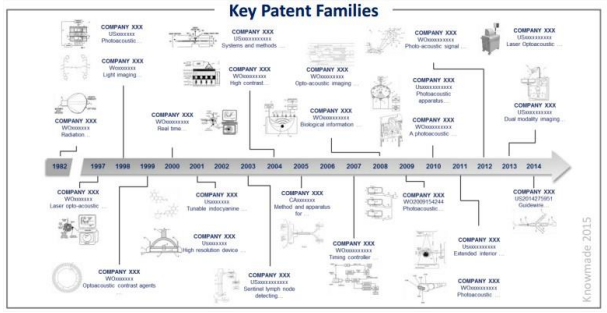
✓ Patents related to various OCT modalities (TD-OCT, FD-OCT, SD-OCT, SS-OCT, low coherence interferometry, etc.)

Not included in the report

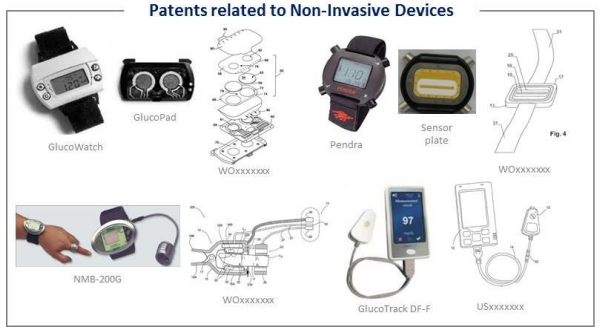
X Patents related to OCT technology for other applications, such as industrial applications (NDT or material thickness measurements)

INTRODUCTION
Related Reports

You may also be interested in our previous reports:



Biomedical Photoacoustic Imaging Patent Landscape



Non-Invasive Glucose Monitoring Patent Landscape

METHODOLOGY

Patent Search, Patent Selection, Patent Analysis (1/2)

- The data were extracted from the **FamPat worldwide database** (Questel-ORBIT) which provides 90+ million patent documents [illegible] offices.

- The search for patents was performed in **October 2017**, hence patents published after this date will not be available in this report.

- The patents were grouped by **patent family**. A patent family is a set of patents filed in multiple countries to protect a single invention by a common inventor(s). A first application is made in one country – the priority country – and is then extended to other countries.

- The **selection of the patents** has been done both **automatically** and **manually** (all details in next slides).

Number of selected patent families for Optical Coherence Tomography:

4,874 over a number of returned results > 5,850

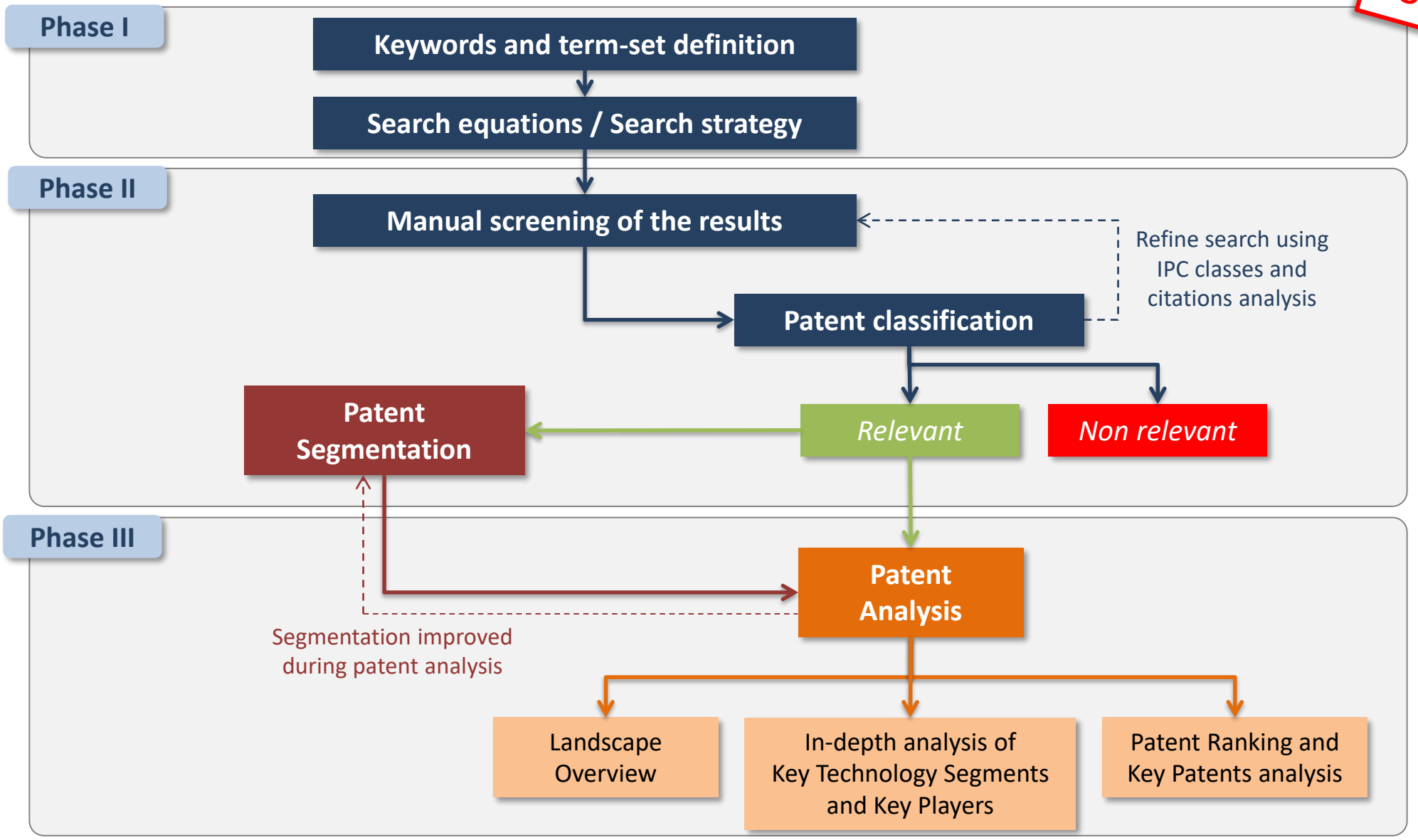
- The statistical analysis was performed with **Orbit IP Business Intelligence web based patent analysis software from Questel**.

- The patents were **manually categorized in technical segments** using keyword analysis of patent title, abstract and claims, in conjunction with expert review of the subject-matter of inventions (all details in next slides).

- For legal status of European (EP) and PCT (WO) patent applications, EPO Register Plus has been used. For legal status of US patents, USPTO PAIR has been used. For legal status of other patents, information has been gotten from their respective national registers.

METHODOLOGY

Patent Search, Patent Selection, Patent Analysis (2/2)



METHODOLOGY

Search Strategy

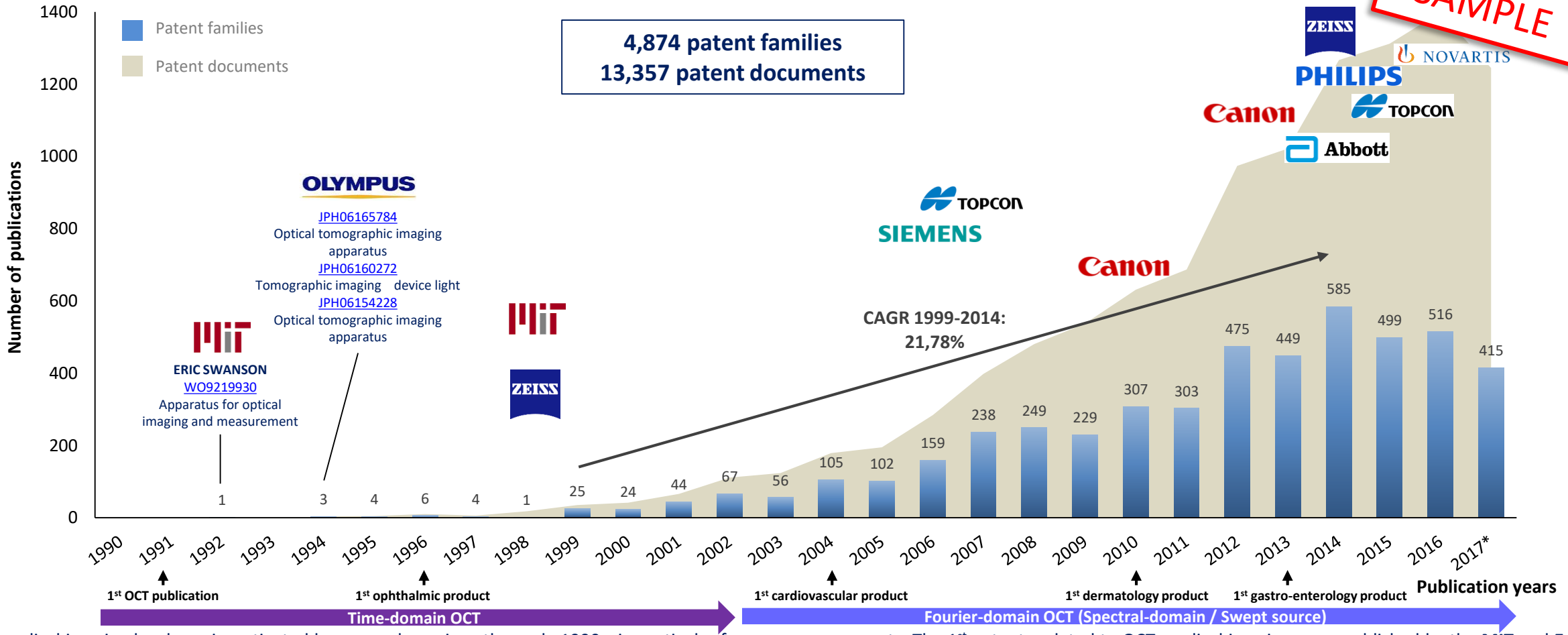
	Step	Search Equation	Results
Patent Related to Optical Coherence Tomography	**Step 1**	((OPTIC+ S TOMO_GRAPH+) P (COHEREN+ OR INTERFEREN+ OR REFLECTOMET+ OR OCT))/BI/CLMS/OBJ OR (OCT/TI) OR (A61B-003/102 OR G01B-009/02091)/CPC/IPC	>5,850
Citing and Cited Patents	**Step 2**	CITING AND CITED PATENTS OF SELECTED PATENTS FROM STEP 1	>35,000
Manual Selection	**Step 3**	**SELECTED PATENT FAMILIES**	**4,874**

- + Truncation replacing any number of characters
- ? Truncation replacing zero or one character
- # Truncation replacing one character
- _ Truncation for word that may have a space (ex: semiconductor, semi conductor)
- OR Finds references containing at least one of the words
- AND Finds references containing all words
- S Finds references containing the terms in the same sentence
- nD Finds references containing adjacent terms, regardless of the order, and may be separated by a maximum of n words

- ( ) Parentheses are necessary to combine different operators
- /TI/OTI Search in Title
- /BI Search in Title and Abstract
- /CLMS Search in Claims
- /OBJ Search in the object of the invention
- /PA.FLD Search in Patent Assignees
- /IC Search in International Patent Classification (IPC)

PATENT LANDSCAPE OVERVIEW

Time Evolution of Patent Publications



OCT medical imaging has been investigated by researchers since the early 1990s, in particular for eye measurements. The 1st patents related to OCT medical imaging were published by the **MIT** and **Eric Swanson** in 1992. Applicants and inventors of this 1st patent are part of the MIT's team behind the 1st scientific publication the previous year. **APPLICANT XXX** and **APPLICANT XXX** also appear among the 1st patent applicants in the domain. The level of patent publications remained low until the years 2000s. In 2006/2007, we observe an increase of publications related to new applicants as well as an increasing activity of applicants such as **APPLICANT XXX** and **APPLICANT XXX**. In 2010, **APPLICANT XXX** appears as a major patent applicant. The company published 48 new applications in 2010, and over 50 applications each year between 2011 and 2015. The number of new publications of **Canon** has slightly decreased in the last couple of years. Main patent applicants in the last 5 years include **APPLICANT XXX, APPLICANT XXX, APPLICANT XXX, APPLICANT XXX, APPLICANT XXX** and **APPLICANT XXX**.

*The data of 2017 are not complete as the patent search has been done in October 2017.

PATENT LANDSCAPE OVERVIEW

Time Evolution by Country of Filing

FILING COUNTRY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	201
CHINA							1				1	1	4	2	2	13	24	45	45	51	49	61	178	149	156	171	179	151
GERMANY (EP)							1	2		7	4	11	9	7	16	22	19	34	28	35	43	28	19	13	29	30	32	23
EUROPE						1	2		4	5	5	9	13	13	15	29	49	68	91	74	66	95	112	125	147	148	168	130
JAPAN					3	2	3	1	2	11	12	23	29	23	37	48	78	110	136	117	149	153	161	212	221	214	268	219
KOREA														1	4	5	6	12	14	10	10	25	60	57	90	45	57	36
RUSSIA							1				1	1	2		5	5	3	4	3	9	15	7	18	24	15	25	15	14
USA					1	1	5	1	5	13	14	17	39	53	62	72	97	150	148	156	197	230	312	321	434	379	367	300
WO (PCT)							2	2	8	2	6	14	24	25	42	40	74	80	94	79	124	138	164	161	225	184	211	153

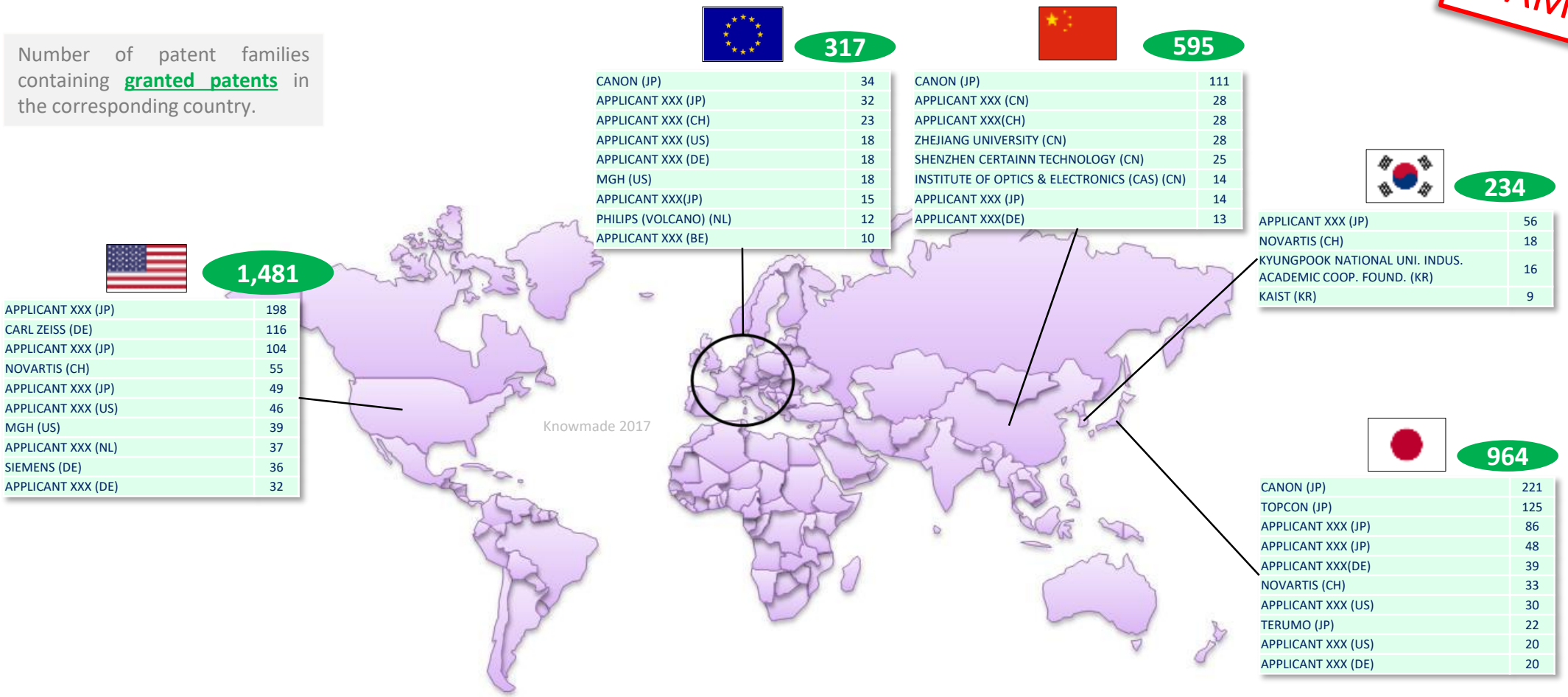
1-9 patent families | 10-19 patent families | 20-29 patent families | 30-39 patent families | 40-49 patent families | 50-99 patent families | ≥100 patent families

In **USA and Japan**, we observe 4 periods of patent publications: a 1st small increase of publications in 1999 and a 2nd in 2003/2004, then the number of publications is booming in 2007 and skyrocketing in 2012. We observe similar trends in **Europe and China** with a slight delay in time. There is an increase of patent publications between 2012 and 2016 in **Korea**, this could be linked to the patenting activity of the Korean **APPLICANT XXX** and **APPLICANT XXX** as well as the activity of the Japanese **APPLICANT XXX**. The number of **PCT publications** is very also high since 2010, showing the worldwide IP strategies of many patent applicants.

PATENT LANDSCAPE OVERVIEW

Mapping of Main Current IP Holders

Number of patent families containing **granted patents** in the corresponding country.

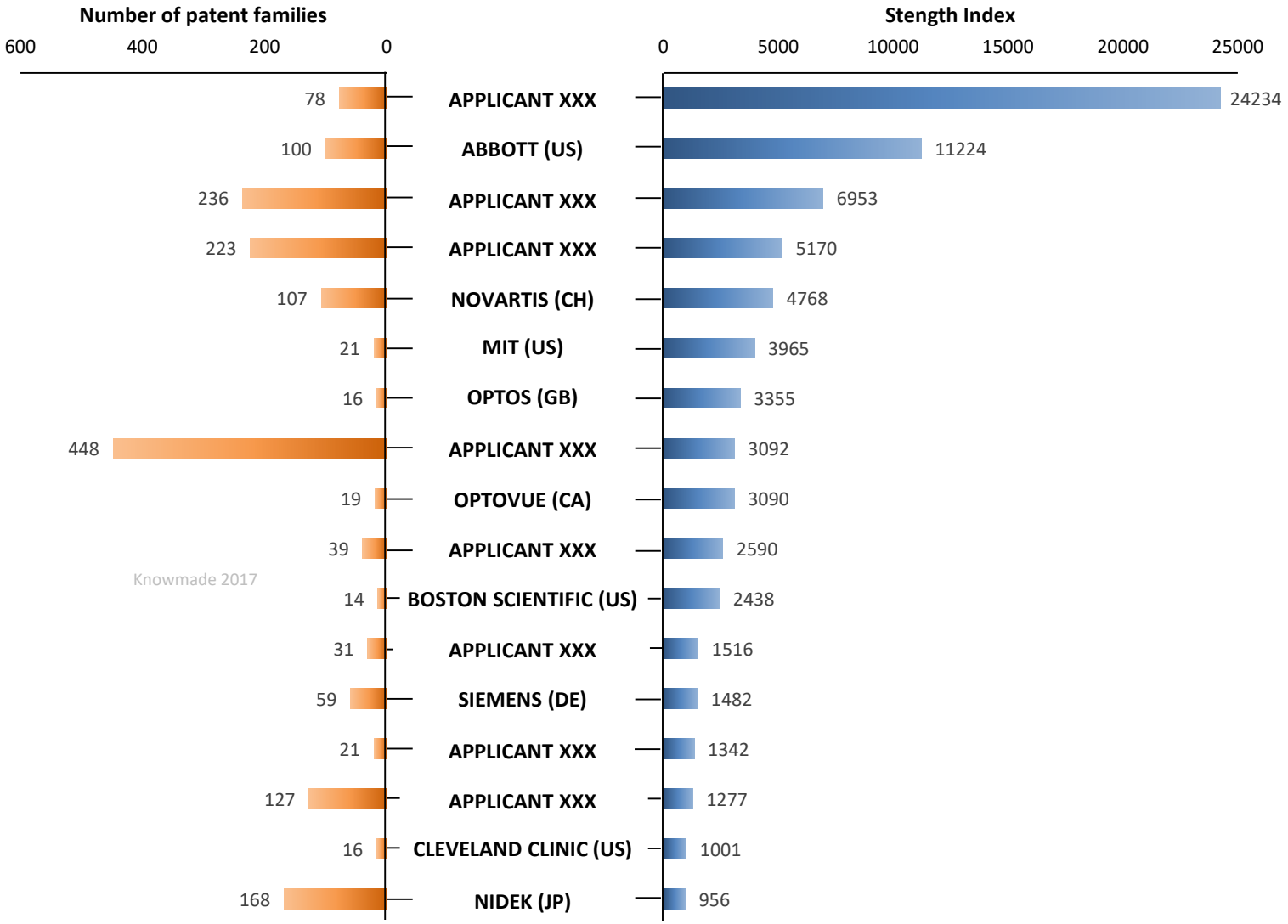


Globally all main patent applicants show a worldwide IP strategy. **APPLICANT XXX** is the main IP holder in all countries, its main granted portfolios are in Japan and USA. Companies such as **APPLICANT XXX, APPLICANT XXX** or **APPLICANT XXX** have also important granted portfolios in several territories.

Unusually, in the USA, main IP holders are Japanese and European. The 1st American IP holders in the country are **APPLICANT XXX** and **APPLICANT XXX**, ranked 6th and 7th with less than 50 families with granted patents. In Japan, the ranking of main IP holders includes several national applicants (**APPLICANT XXX, APPLICANT XXX, APPLICANT XXX, APPLICANT XXX**), as well as European applicants (**APPLICANT XXX, APPLICANT XXX, APPLICANT XXX**). **APPLICANT XXX and APPLICANT XXX** are once more the main US applicants in Japan. In China, the Japanese **APPLICANT XXX** is the main IP holder, but several national academics applicants show a significant patenting activity.

IP POSITION OF MAIN PATENT ASSIGNEES

Strength Index of Patent Portfolios (1/2)



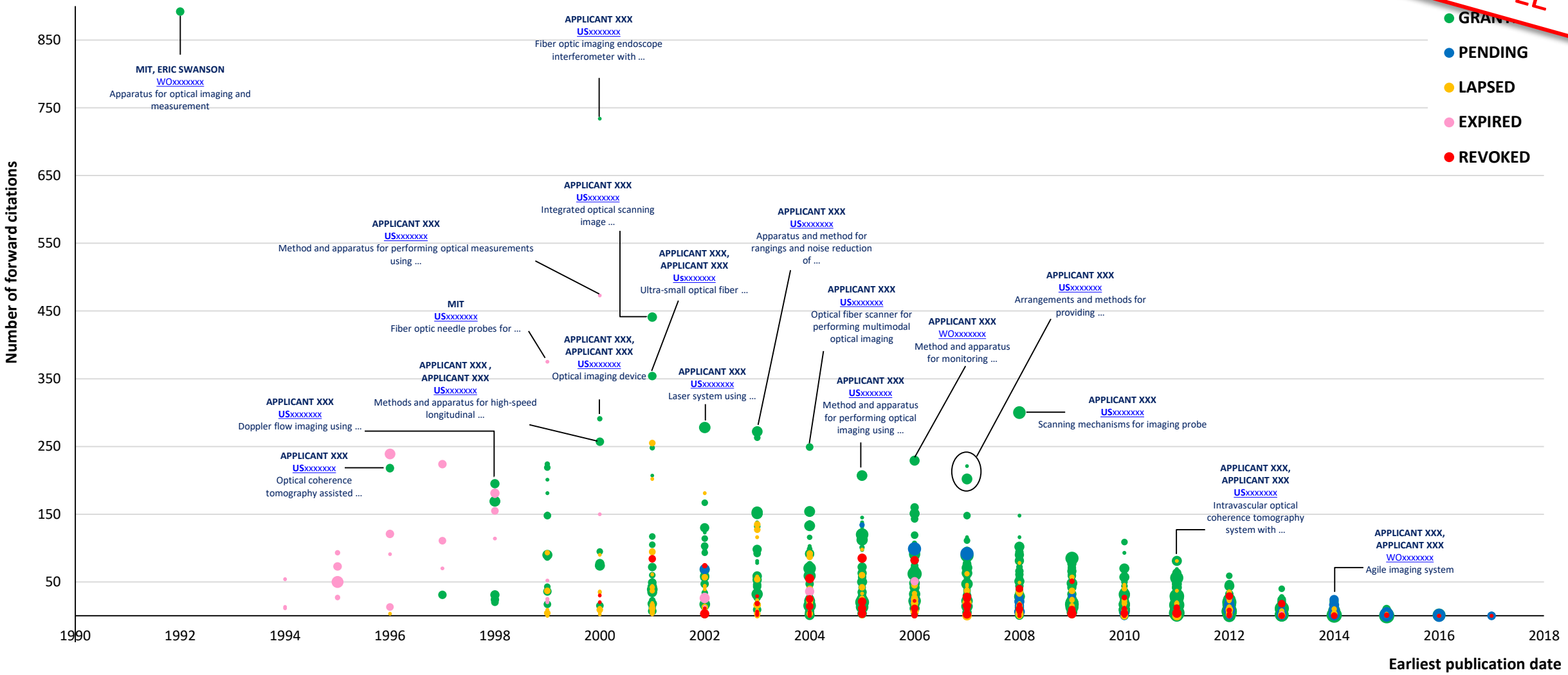
In an IP landscape, the number of patents assigned to a [illegible] necessarily reflect the strength of its portfolio. So, we analyzed the [illegible] index of the portfolio of patent applicants in the domain of OCT for biomedical imaging based on citations, geographical coverage and number of granted patents (described in the next slide).

Despite its very large portfolio, **APPLICANT XXX** shows an average Strength index. Its portfolio doesn't receive many citations and its geographical extension is average compare to other main applicants. With smaller portfolios, **APPLICANT XXX and APPLICANT XXX** show a higher number forward citations, a large geographical coverage as well as a great number of granted patents per family in average. Therefore, both applicants display very high Strength index. Main citing applicants of **APPLICANT XXX**'s portfolio include **APPLICANT XXX, APPLICANT XXX, APPLICANT XXX and APPLICANT XXX**. **APPLICANT XXX**'s portfolio is mainly cited by **APPLICANT XXX, APPLICANT XXX, APPLICANT XXX** and **APPLICANT XXX**. Contrary to **APPLICANT XXX**, **APPLICANT XXX** and **APPLICANT XXX** remain at the top ranking of the Strength index analysis. **APPLICANT XXX** shows the higher geographical coverage and the higher average number of granted patents per family. These factors give **APPLICANT XXX** an important Strength index. **APPLICANT XXX** owns a small portfolio dedicated to OCT imaging, but it receives a huge number of forward citations, suggesting a strong technological impact of these patents. This ranked **APPLICANT XXX**'s portfolio 6th in the Strength index ranking. The portfolio is cited many times by **APPLICANT XXX, APPLICANT XXX** and **APPLICANT XXX** for examples. The British company **APPLICANT XXX** has also developed an interesting portfolio with a large geographical coverage and a significant number of granted patents in each family. **APPLICANT XXX** and **APPLICANT XXX** appear at the bottom of the Strength index ranking. This low strength index is mainly due to their low number of granted patents per family.

For the next part of the IP landscape analysis, we will focus on the IP activity of the 17 patent assignees shown in this Strength index ranking. The next slide shows more details on the citation analysis.

IP POSITION OF MAIN PATENT ASSIGNEES

Patent Citation Analysis

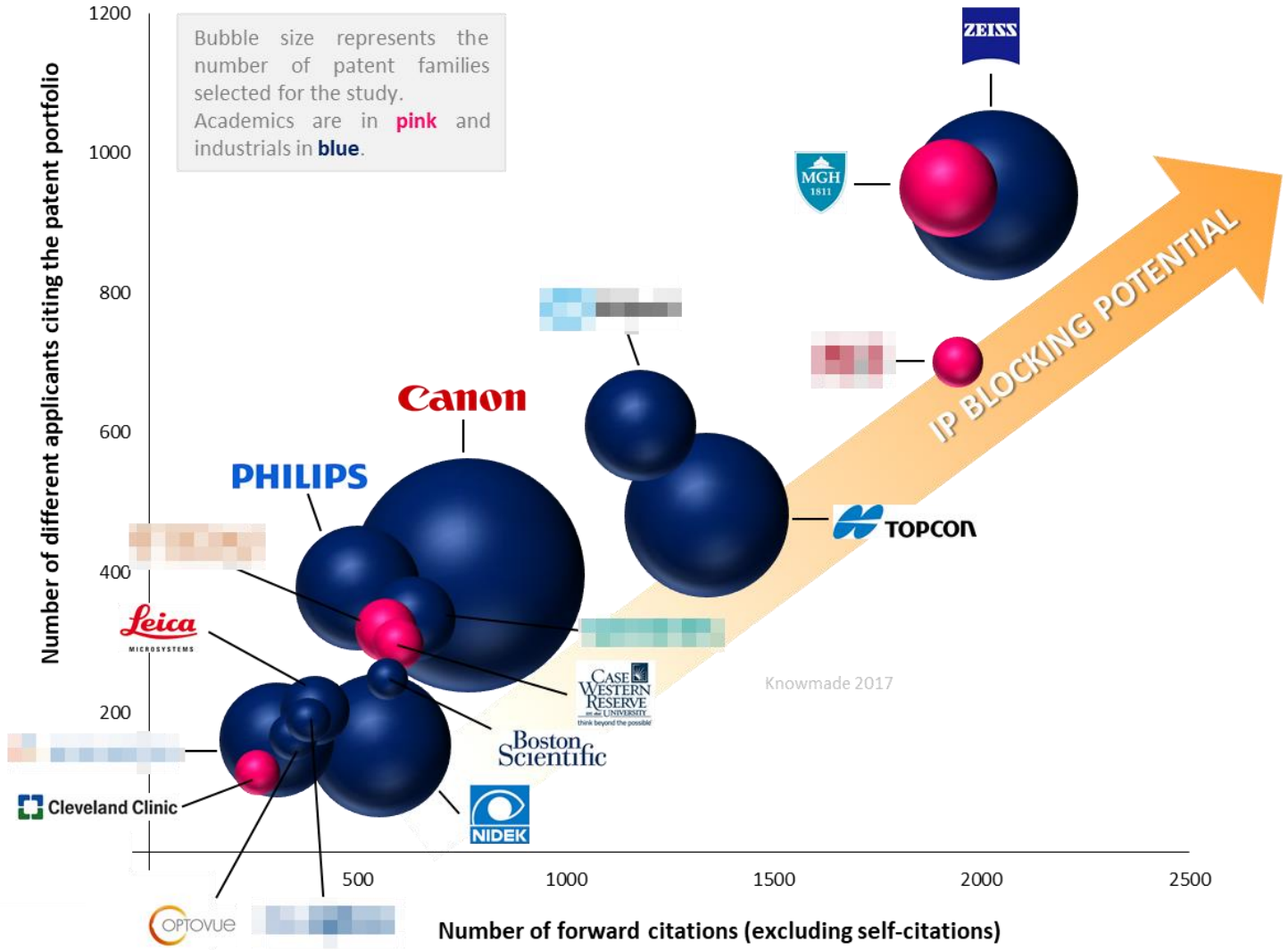


Each bubble represents a patent family and bubble size represents the number of countries/authorities in which patents are published.

Granted: at least one patent is granted; **Pending**: at least one application is pending; **Lapsed**: all patents are lapsed; **Expired**: all patents are expired; **Revoked**: all patents are revoked

IP POSITION OF MAIN PATENT ASSIGNEES

IP Blocking Potential of Patent Applicants



Despite the size difference of their portfolios, **Zeiss** [illegible] similar IP blocking potential, both applicants having several p[illegible] highly cited by various other applicants. **APPLICANT XXX** owns patents among the most cited of this landscape, such as: USxxxxxxx, USxxxxxxx or USxxxxxxx. **APPLICANT XXX, APPLICANT XXX and APPLICANT XXX** are the Top-3 most citing applicants of **APPLICANT XXX**'s portfolio. Most cited patents of **APPLICANT XXX**'s portfolio include US6004314 and USxxxxxxx. Main citing applicants for **APPLICANT XXX** are **APPLICANT XXX, APPLICANT XXX and APPLICANT XXX**. Pioneer of the OCT technology, **APPLICANT XXX** also shows a significant IP blocking potential, with only 21 families in its portfolio. Several of its patents feature among the most cited patents (WOxxxxxxx, USxxxxxxx published with **APPLICANT XXX**, USxxxxxxx). The main applicants citing **APPLICANT XXX**'s portfolio are **APPLICANT XXX, APPLICANT XXX and APPLICANT XXX**.

The Japanese **APPLICANT XXX** holds by far the largest portfolio of this landscape. However, the company shows a low IP blocking potential compare to **APPLICANT XXX, APPLICANT XXX and even APPLICANT XXX** because its portfolio received less citations from other applicants. **APPLICANT XXX**'s portfolio is also younger than those 4 applicants. Main citing applicants of **APPLICANT XXX**'s patents include **APPLICANT XXX, APPLICANT XXX, APPLICANT XXX and APPLICANT XXX**.

The more the number of forward citations from different patent applicants is high, the more the capacity to hamper the other firms' attempts to patent a related invention is important.

Note: This graph is at patent family level. The identification of a "blocking patent" requires an in-depth specific analysis of each patent document composing the patent families. The IP blocking potential is an indicator of how an IP player and its patents are difficult to circumvent in a technology. The IP blocking potential is not necessarily linked to the size of the portfolio.

IP POSITION OF MAIN PATENT ASSIGNEES

Summary of Applicant's Patent Portfolio (1/2)

ASSIGNEE	No. of patent families	Oldest priority date of the portfolio	No. of families filed / yr (average)	No. of patent documents	No. of patents / Family (average)	Patent average age (yr)	% granted	% pending	% dead (revoked lapsed expired)	No. of alive patents / Family (granted, pending)	No. of granted patent families by country				
											US	EP	JP	CN	KR
APPLICANT XXX	448	2006	xx	xx	xx	4	38%	xx%	xx%	2.9	198	34	221	111	56
APPLICANT XXX	xx	19xx	9.8	xx	5.6	6	xx%	xx%	xx%	xx	116	18	39	13	-
APPLICANT XXX	xx	19xx	xx	1,578	xx	xx	xx%	15%	xx%	xx	104	32	125	14	-
APPLICANT XXX	168	20xx	xx	xx	xx	xx	31%	xx%	xx%	xx	49	15	86	-	-
APPLICANT XXX	xx	2000	xx	857	xx	xx	19%	xx%	53%	3.2	37	12	14	7	-
APPLICANT XXX	107	20xx	xx	xx	xx	3	xx%	33%	xx%	xx	55	23	33	28	18
APPLICANT XXX	100	19xx	xx	xx	xx	xx	xx%	xx%	46%	6.4	46	18	20	10	-
APPLICANT XXX	78	1991	xx	xx	18.9	xx	xx%	7%	xx%	6.4	39	18	30	-	-
APPLICANT XXX	xx	20xx	3.9	141	2.4	xx	60%	xx%	31%	1.6	36	20	20	2	-
APPLICANT XXX	xx	2003	xx	xx	xx	6	xx%	17%	xx%	xx	32	3	3	4	-
APPLICANT XXX	xx	1998	xx	165	xx	xx	28%	xx%	xx%	xx	17	1	2	-	-
APPLICANT XXX	xx	19xx	1.1	xx	4.9	9	xx%	xx%	xx%	2.1	15	2	1	-	-
APPLICANT XXX	21	1991	xx	93	xx	11	33%	xx%	xx%	xx	8	2	2	-	-
APPLICANT XXX	xx	20xx	xx	xx	12.5	xx	xx%	xx%	xx%	xx	14	3	7	9	-
APPLICANT XXX	xx	19xx	0.8	145	xx	11	xx%	12%	xx%	4.6	14	7	2	1	1
APPLICANT XXX	xx	20xx	xx	xx	8.8	xx	xx%	xx%	xx%	xx	7	2	-	-	-
APPLICANT XXX	14	1996	xx	xx	xx	11	xx%	4%	70%	xx	8	1	4	-	-

highest value in column lowest value in column

IP POSITION OF MAIN PATENT ASSIGNEES

Summary of Applicant's Patent Portfolio (2/2)

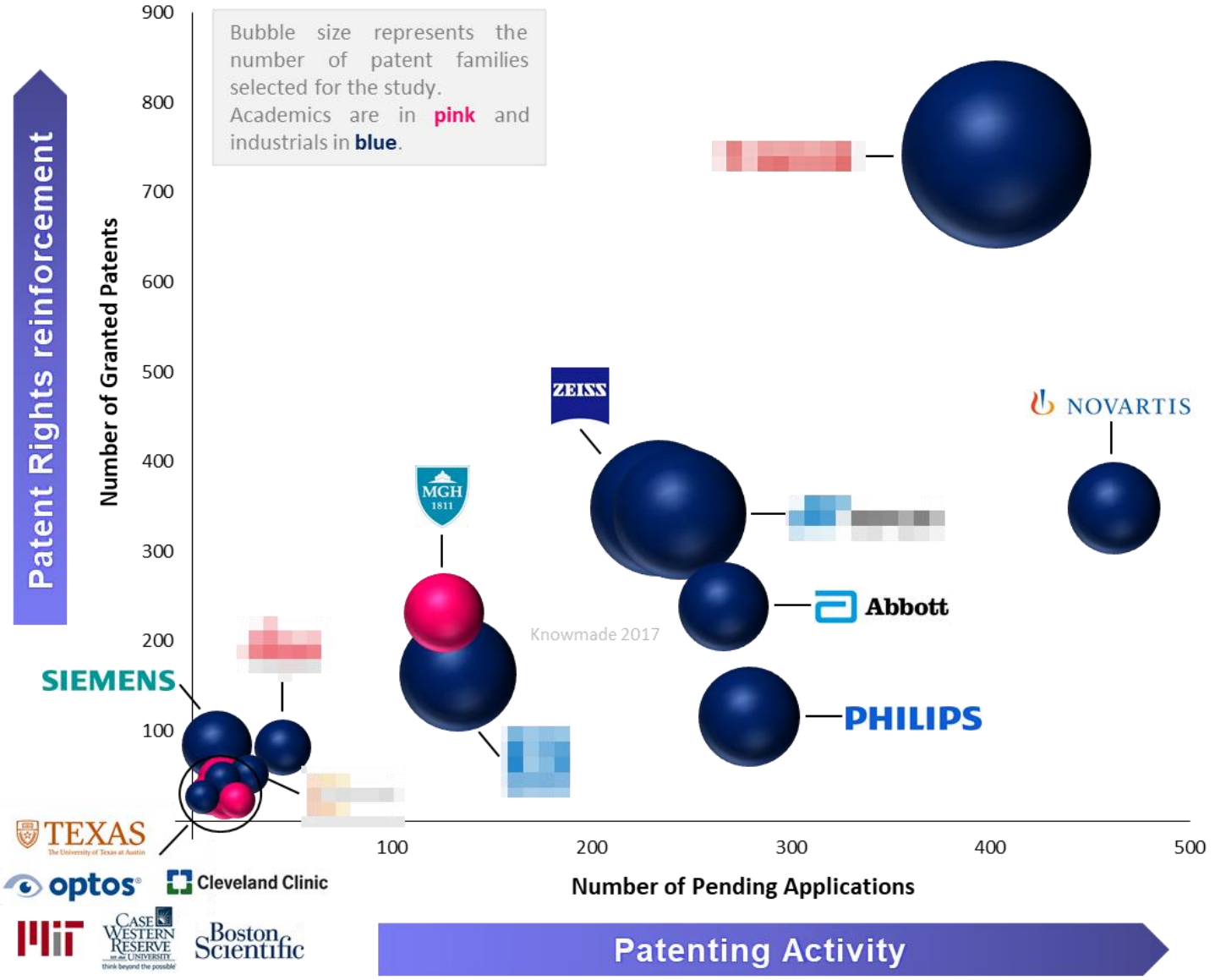
Among the main applicant, **APPLICANT XXX** is the pioneer of OCT technology. The American institute owns several seminal patents: WOxxxxxxx (pub[illegible] 1992), USxxxxxxx (published in 1999), USxxxxxxx (published in 2000). The OCT research team of the **APPLICANT XXX** has also had an important contribution to the translation of the technology to the market, creating a couple of spin off including **APPLICANT XXX** and **APPLICANT XXX**. Both startups were later acquired by big companies, **APPLICANT XXX and APPLICANT XXX** , which are currently important IP and market players in the OCT domain.
APPLICANT XXX owns the 2nd largest portfolio dedicated to OCT medical imaging (236 families, over 1,300 patents). The company holds a lot of granted patents in the US, but also in Japan, China and Europe. The IP activity of **APPLICANT XXX** is relatively steady, indicating a constant interest in this technology. Moreover, **APPLICANT XXX** has several ophthalmology OCT devices on the market (ophthalmoscopes, surgical microscopes) and has launched new products with advanced angiography capabilities recently. Therefore, Zeiss is a very important player in the OCT patent landscape.
St Jude Medical develops intravascular diagnostics and imaging system using OCT. In 2017, **APPLICANT XXX** was acquired by **APPLICANT XXX**. With 100 patent families and over 1,200 patents, **APPLICANT XXX** owns a quite large patent portfolio. Moreover, in average, a family includes over 6 alive patents, which is the highest ratio of this landscape. **APPLICANT XXX** holds numerous granted patents worldwide, as well as many worldwide pending applications (over 50 families with pending applications in USA and Europe). The acquisition of **APPLICANT XXX** brought to **APPLICANT XXX**'s portfolio several important patent families, such as USxxxxxxx, USxxxxxxx, USxxxxxxx. **APPLICANT XXX**'s OCT IP portfolio is focusing on cardiovascular imaging application.

APPLICANT XXX is also an important IP player in OCT imaging technology. This American institute started to publish patents in the domain in the 2000s. Today, with over 1,400 patents split into 78 families, **APPLICANT XXX** shows the highest average number of patent per family. Moreover, its portfolio also displays the highest ratio of alive patents per family, equal to **APPLICANT XXX** . The importance of **APPLICANT XXX**'s portfolio in the OCT imaging IP landscape has also been revealed previously by its strength index ranking. Indeed, the portfolio of **APPLICANT XXX** , ranked 1st, is far before **APPLICANT XXX**. Applications targeted by **APPLICANT XXX** include both cardiovascular and ophthalmology.

Latest to enter the IP landscape for OCT imaging, **APPLICANT XXX** quickly became the biggest IP holder in the domain. Since 2006, **APPLICANT XXX** has filed 448 families including over 2,400 patents. The company shows a worldwide strategy, filing patents in many countries (Japan, USA, China and Europe). However, the impact **APPLICANT XXX**'s portfolio on OCT imaging landscape is still limited. In particular, its portfolio has not received many forward citations compare to other applicants in the domain. However, **APPLICANT XXX** already has ophthalmology OCT devices on the market, and its patent portfolio could gain more importance in the future.

IP POSITION OF MAIN PATENT ASSIGNEES

IP Leadership of Patent Applicants



APPLICANT XXX shows by far the strongest [illegible] position. The Japanese company developed a very large portfolio combining a very high number of granted patents (over 700) and pending applications (over 400). Among the main patent applicants, **APPLICANT XXX** looks like a new comer in the OCT imaging IP landscape. Its patenting activity in the domain only goes back to 2006/2007. **APPLICANT XXX** is also an important market player in OCT ophthalmology.

The Swiss **APPLICANT XXX** is also in an interesting leadership position. However, this could change in the near future if **APPLICANT XXX** decides to spin off **APPLICANT XXX**, its subsidiary specialized in femtosecond laser technology.

Historical IP players in OCT imaging, **APPLICANT XXX** and **APPLICANT XXX** show a significant leadership. Both companies own a solid granted portfolio and have increase their patenting activity during the last 5 years.

APPLICANT XXX is also well ranked. The company showed its interest in the OCT imaging and strengthened its portfolio with the recent acquisition of **APPLICANT XXX**.

APPLICANT XXX shows an important recent patenting activity in link with the acquisition of **APPLICANT XXX**.

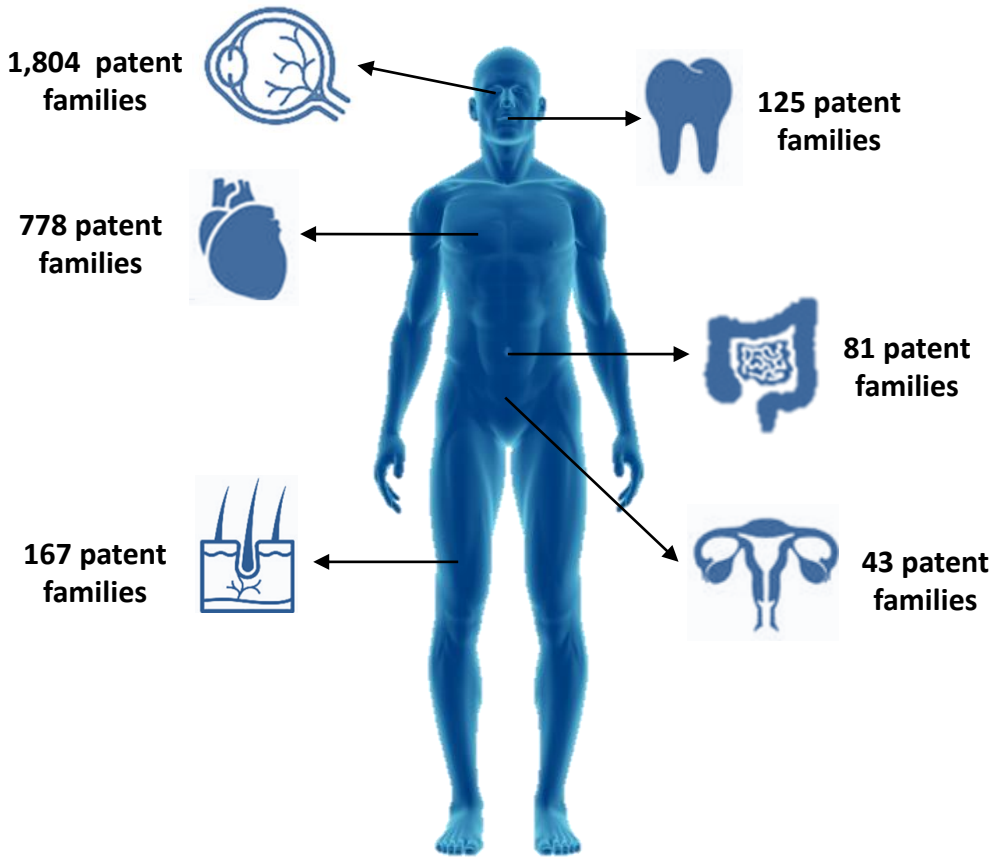
APPLICANT XXX is the academic applicant with the strongest leadership in OCT imaging IP. Its leadership is similar to the Japanese **APPLICANT XXX**.

ANALYSIS BY APPLICATION

Technical Segmentation by Application (1/2)

In order to fully understand the technological issues, we also classified the patents according to the main medical applications for OCT imaging:

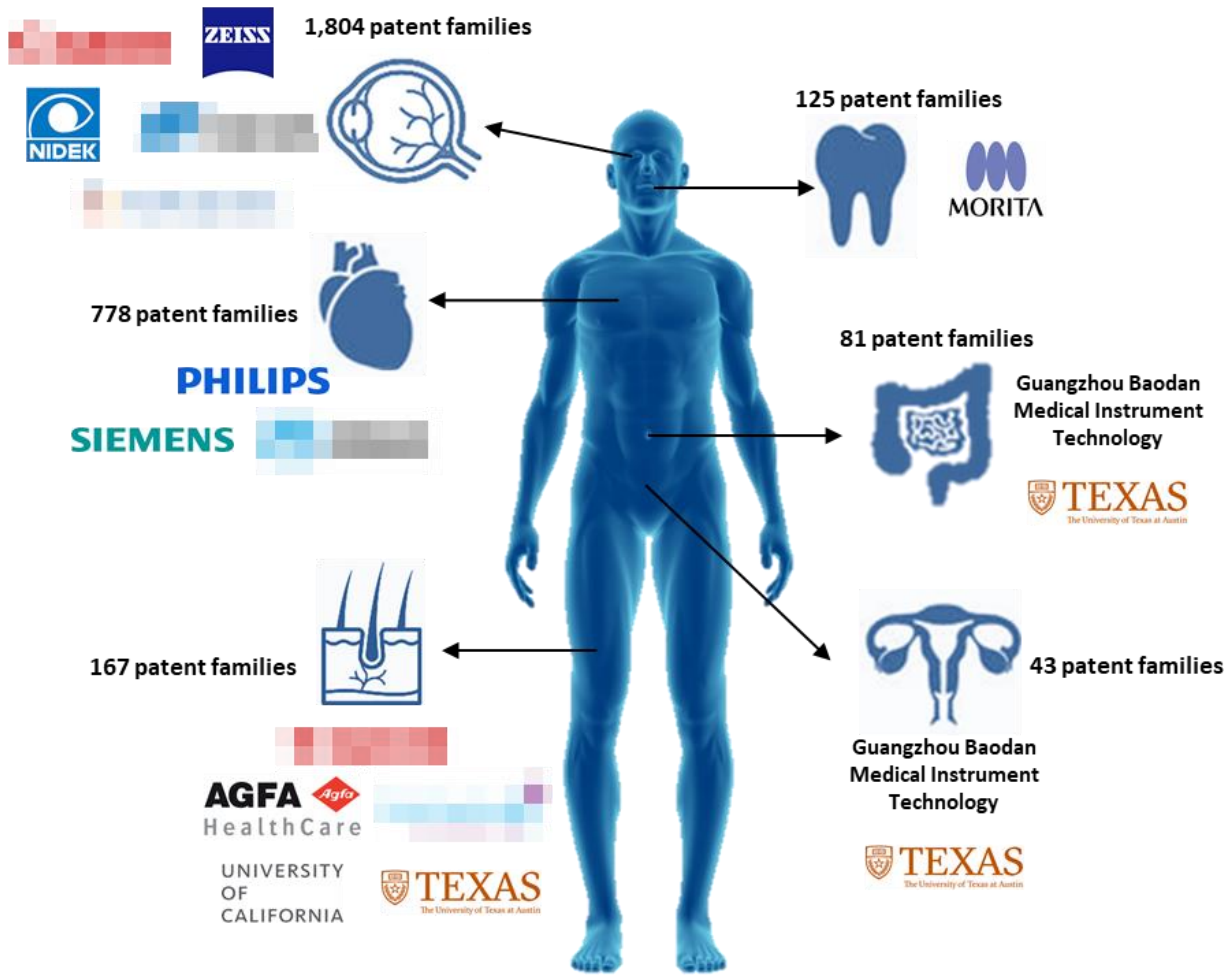
APPLICATIONS	SEARCH EQUATION (title, abstract, claims)
Cardiovascular/ Intravascular	HEART OR VESSEL? OR ANGIOGRAPH+ OR +VASCULAR+ OR ATHERECT+ OR ARTERY OR CATHETER+ OR CORONAR+ OR +VEIN+ OR +CARDIO+
Dentistry	DENTAL OR DENTIST+ OR MOUTH OR TEETH OR TOOTH OR ORAL OR INTRA_ORAL OR CARIES OR PERIODONTAL
Dermatology	SKIN OR EPIDERM+ OR DERMAT+
Gastro-enterology	GASTRO_ENTEROLOG+ OR +INTESTIN+ OR PANCREAS OR BILE OR COLON OR LIVER OR COLOSCOP+ OR ESOPHAG+ OR LARYNX OR LARYNGO+
Gynecology	GYNECO+ OR HYSTER+ OR UTERUS OR UTERINE OR FALLOP+ OR OVAR+ OR COLPOSCOP+ OR VAGIN+ OR CERVIX OR CERVICAL
Ophthalmology	EYE? OR OPHTHALM+ OR RETINA? OR CORNEA? OR FUNDUS OR OCUL+ OR CATARACT OR GLAUCOMA



Other/unspecified: 2,188 families

ANALYSIS BY APPLICATION

Technical Segmentation by Application (2/2)



Ophthalmic applications are really dominant in OCT tec
Unsurprisingly, several main applicants have invested in the IP development of these applications, including **APPLICANT XXX, APPLICANT XXX, APPLICANT XXX, APPLICANT XXX and APPLICANT XXX**. All those applicants, or their subsidiaries, have related products on the market.

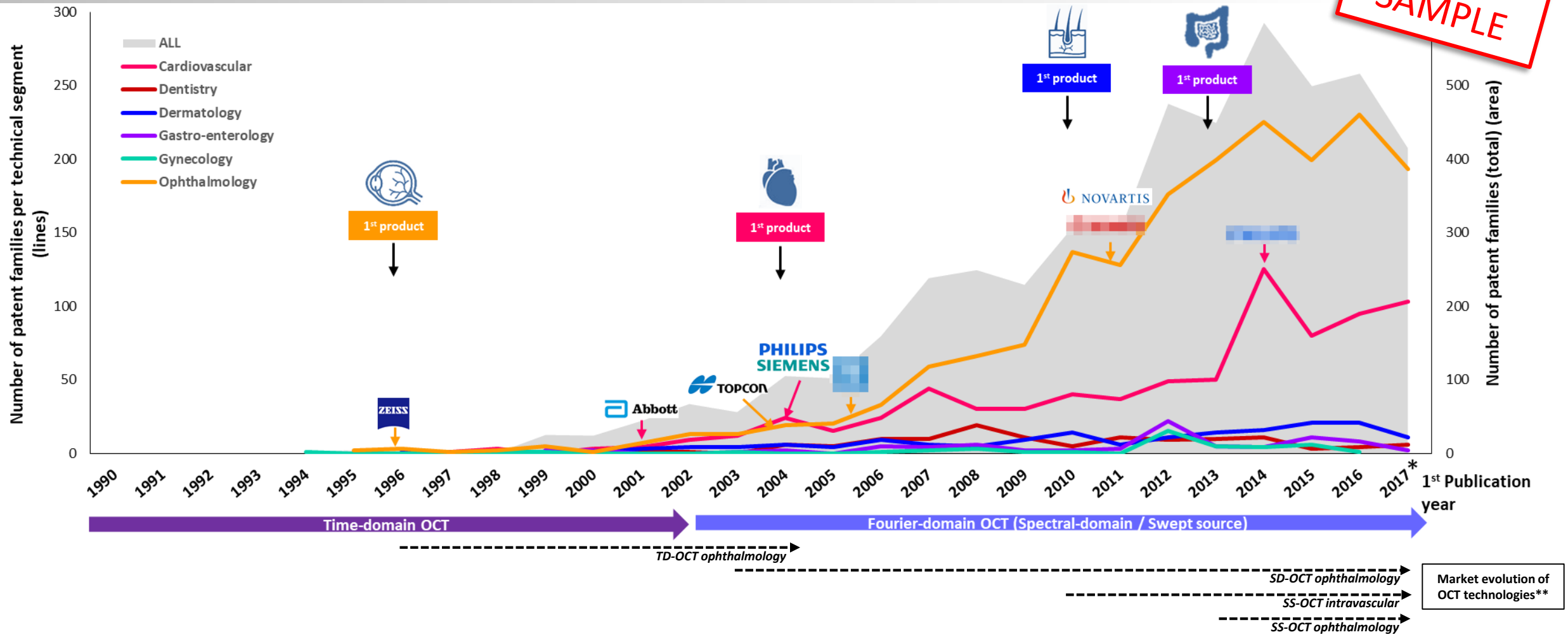
The 2nd medical application for OCT is cardiovascular and intravascular imaging. This domain involves totally different applicants compare to ophthalmology. Main applicants in this segment are **APPLICANT XXX, APPLICANT XXX and APPLICANT XXX**. **APPLICANT XXX and APPLICANT XXX** entered the IP sphere of OCT with the acquisition of **APPLICANT XXX and APPLICANT XXX** respectively. In the cardiovascular/intravascular segment, OCT is in competition with ultra-sound imaging which is a well-established technology on the market. Through **APPLICANT XXX**, **APPLICANT XXX** commercializes OCT cardiovascular imaging systems (integrated systems and intravascular imaging catheters).

OCT for other applications is much less developed in patents. However, some products are already available on the market, such as OCT endoscopes for gastroenterology. For instance, **APPLICANT XXX** offers NvisionVLE Imaging System for esophagus examination. In dermatology, **APPLICANT XXX** provides VivoSight. Another company, **APPLICANT XXX,** received the CE Mark certification for NITID, an OCT skin diagnostic solution, in 2015.

Academics applicants feature among main applicants for dermatology, gastroenterology and gynecology applications. This indicates that OCT technology for these applications is not mature yet.

ANALYSIS BY APPLICATION

Time Evolution by Application



The development of OCT for medical imaging started in the early 1990s. In the early 2000s, 2 applications are standing out: **cardiovascular and ophthalmic applications**. Since 2005, the number of patents related to OCT for **ophthalmology** has been increasing greatly, whereas patents claiming **cardiovascular application** have increased at a slower pace. The peak observed in 2014 in this segment is due to an intense IP activity of **APLICANT XXX.** Ultra-sound represents another well-developed cardiovascular imaging technology. Moreover, ultra-sound and OCT are analogous imaging modality. Therefore, the IP development of OCT in this domain may suffer from a competition with ultra-sound. The use of OCT in the other medical segments is still in development and the number of patent publications is still very low.

*The data of 2017 are not complete as the patent search has been done in October 2017. **Yole Développement, Solid-State Medical Imaging Market & Technology report (2017)

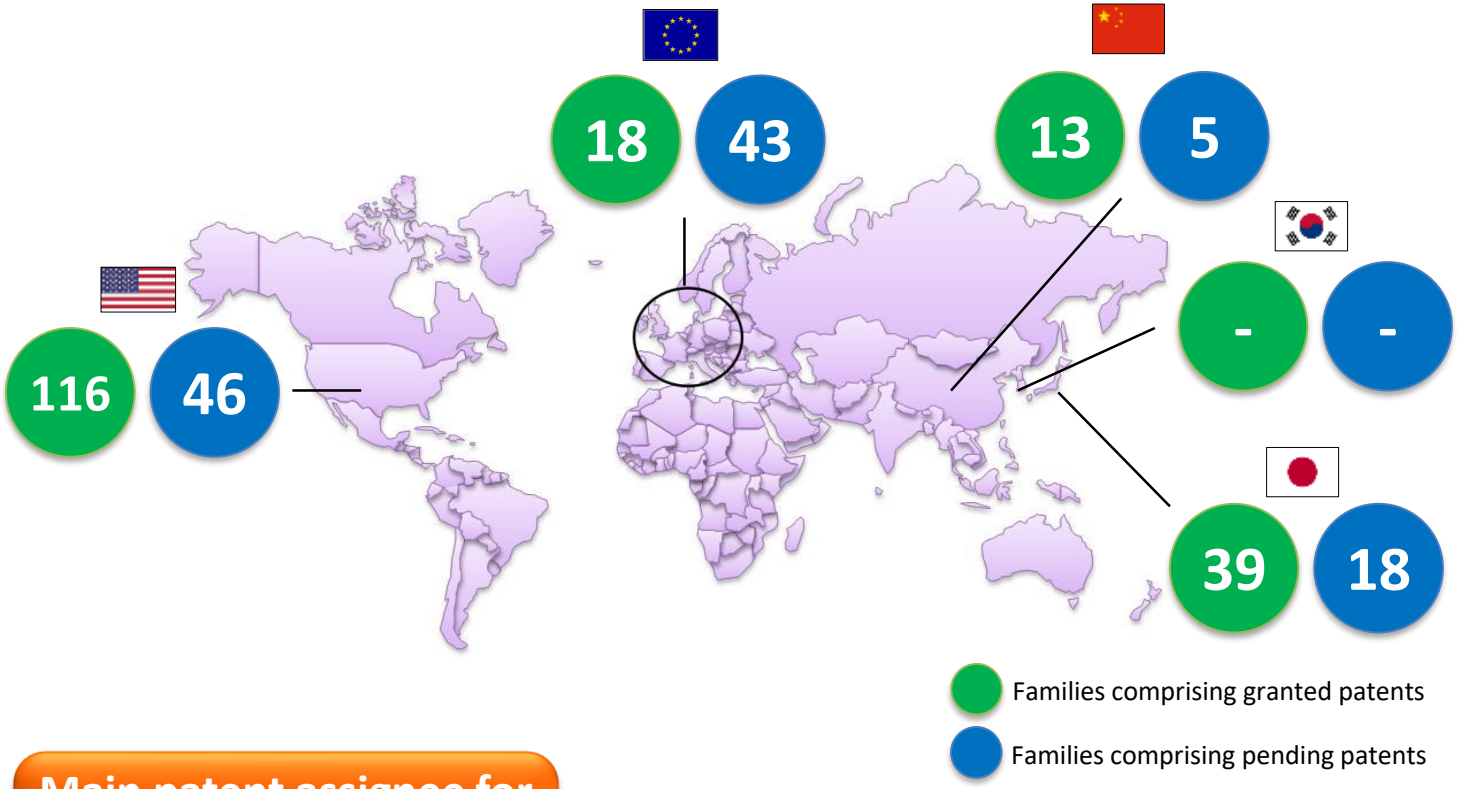
IP PROFILE OF KEY PLAYERS

Applicant XXX

Summary of applicant's patent portfolio

Large portfolio	**1993** Oldest priority date	**6** Patent average age
236 Families	**1,323** Patents	**US, DE** Main countries of filings
348 Granted patents	**234** Pending application	**High** Portfolio Strength
Very high IP Blocking potential	**Medium** Leadership	

Map of granted and pending patents



Main patent assignee for ophthalmology
Pioneer in OCT technology

IP PROFILE OF KEY PLAYERS

Applicant XXX - Key patents

USxxxxxxx

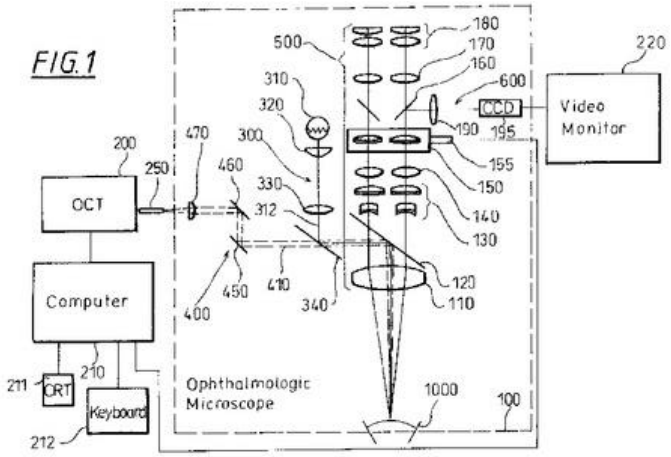
Optical coherence tomography assisted surgical apparatus

1st publication: 19xx

Applicant: XXX

Legal status: granted in JP

Content: An ophthalmologic surgical apparatus comprises a laser for producing laser radiation, laser delivery means for applying the laser radiation to an object and an optical coherence tomography ("OCT") apparatus. The ophthalmologic surgical apparatus has scanning means for scanning the object with optical output from the OCT apparatus, analysis means for analysing detection signals output from the OCT apparatus to determine portions of the object, which have been affected by the application of the laser radiation, and means, in response to output from the analysis means, for interacting with one or more of: (a) the laser, and (b) the delivery means to effect one or more of: (a) an exposure time, (b) a power, and (c) a spot size of the laser radiation.



USxxxxxxx

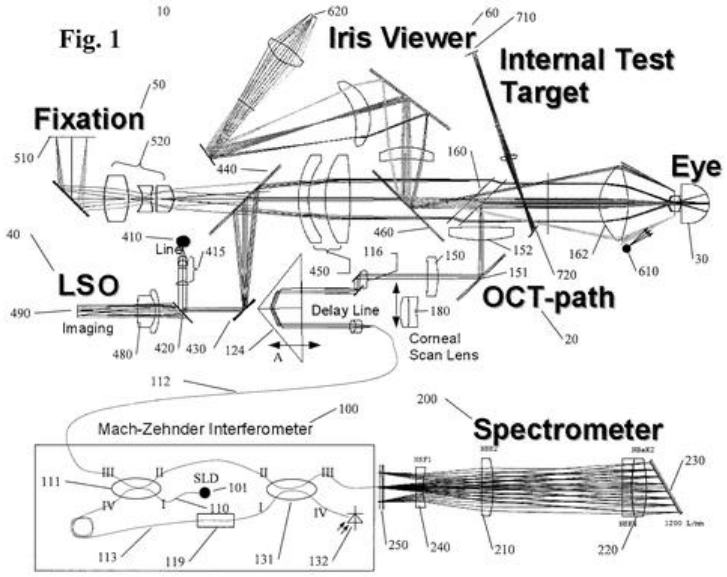
Spectral domain optical coherence tomography system

1st publication: 20xx

Applicant: XXX

Legal status: granted in US

Content: An optical coherence tomography device is disclosed for improved imaging. Reduced levels of speckle in the images generated by the device are obtained by forming a B-scan from a plurality of A-scans, wherein each resolution cell of the B-scan is generated through compounding of a subset of the A-scans and wherein at least some of the subset of A-scans are separated by at least half the diameter of a speckle cell both tangent to and orthogonal to the B-scan at that cell.



EXCEL DATABASE

Containing all the patents analyzed in this report with technology segmentation

REPORT SAMPLE

This database allows multi-criteria searches and includes patent publication number, hyperlinks to the original documents, priority date, title, abstract, patent assignees, and legal status for each member of the patent family.

FAMILY NUMBER (FamPat Database)	PATENT NUMBER	PATENTASSIGNEE	PRIORITY DATE	TITLE	ABSTRACT	PDF LINK	LEGAL STATUS	ACTUAL OR EXPECTED EXPIRATION DATE	DENTISTRY	DERMATOLOGY	GASTRO-ENTEROLOGY	GYNECOLOGY	OPHTHALMO-LOGY	INTRAVASCULAR/ CARDIOVASCULAR
57221487	WO20	HANGZHOU	2016-07-19	40)Oct-based in situ 3d printi	40)Equipment used for OCT-ba	Open	PENDING	2020-01-19		X				X
54704081	JP201	BIOPTIGEN	2014-11-07	07)Light beam scanning drivin	07)A scanning optical system i	Open	PENDING	2035-11-06					X	
52666143	EP3	NOVARTIS	2013-09-13	Oct probe with bowing flexor	An OCT probe (300,350,400) for	Open	PENDING	2034-08-14					X	
49161057	EP3	TOPCON	2012-03-12	Image displaying apparatus a	n an embodiment of an imag	Open	PENDING	2033-03-08					X	X
55650709	EP3	DIMANT CHIAM	2015-03-11	System and methods for seria	The present invention relates	Open	PENDING	2036-03-11						
48086239	US20	NORTHWESTERN	2011-10-14	7487)Biological tissue analysis	7487)A method and system to r	Open	PENDING	2032-10-12	X	X	X	X	X	
56977429	US20	TERUMO	2015-03-24	4815)Imaging apparatus for di	4815)A control method, comput	Open	PENDING	2036-03-14						X
56417286	US20	LG ELECTRONICS	2015-01-22	4730)Polarization sensitive opt	4730)Disclosed is a polarizatic	Open	PENDING	2035-06-03		X				
56566382	US20	CARL ZEISS	2015-02-05	4728)Acquisition and analysis	4728)Methods for improved ac	Open	PENDING	2036-02-04					X	X
56564667	US20	UNIVERSITY OF	2015-02-03	4773)Falloposcope and metho	4773)A falloposcope is describ	Open	PENDING	2036-02-03				X		
57504886	US20	NATIONAL RESEARCH	2015-06-08	7499)Real-time inspection of a	7499)A technique for automate	Open	PENDING	2036-06-08						
52876132	US20	MICHAELSON	2015-02-26	8785)Processing optical cohere	8785)A method of processing o	Open	PENDING	2036-02-17		X				
40229215	PT2	JASWANT RATHORE	2007-05-07	)A method and a system for la	)A method for ablating a presl	Open	PENDING	2028-04-15					X	
48905885	PL2	UNIVERSITY OF	2012-02-03	In vivo optical flow imaging	Amplitude decorrelation meas	Open	GRANTED	2023-02-01					X	X
56285095	JP201		2015-01-04	75)System as a reference sign	75)The invention provides a m	Open	PENDING	2036-01-01		X				
56162849	JP201		2014-12-29	23)Surgical visualization syste	23)An ophthalmic visualizatio	Open	PENDING	2035-11-02					X	
56097172	EP3	NOVARTIS	2015-05-19	Oct image modification	According to some examples,	Open	PENDING	2036-05-16					X	
52627041	EP3	MEDIZINISCHE	2015-03-02	Computerized device and meth	A computerized device (100) fc	Open	PENDING	2036-02-29					X	
56879741	EP3	MASSACHUSETTS	2015-03-06	Atherosclerosis imaging agen	Methods for detecting the pres	Open	PENDING	2036-03-07						X
55543099	EP3	NOVARTIS	2015-06-15	Tracking system for surgical op	An OCT tracking system includ	Open	PENDING	2036-03-03					X	
52133047	US20	BELL BIOSYSTEMS	2012-01-13	8728)Eukaryotic Cells with Artifi	8728)The present invention is	Open	PENDING	2034-07-15						
46577900	US20	SUNNYBROOK	2011-01-31	8230)Ultrasonic probe with ult	8230)Methods and apparatus a	Open	PENDING	2032-01-31						
56564763	US20	DUKE UNIVERSITY	2015-02-06	8140)Stereoscopic display syst	8140)Stereoscopic display syst	Open	PENDING	2036-02-05					X	
52277261	SG102	OPHTHOTECH	2013-07-12	8882T)Methods for treating or p	8882T)The present invention re	Open	PENDING	2034-07-11					X	
57550659	CN10	CANON	2015-05-01	05)Image pickup device	05)PROBLEM TO BE SOLVED: To p	Open	PENDING	2036-03-30					X	
56098298	AU20	NOVARTIS	2015-08-04	400)Dynamic surgical data ove	400)A method (300) for display	Open	PENDING	2036-05-24					X	X
57544660	AU20	UNIVERSITY OF	2015-06-15	191)Insertion system and meth	191)A needle insertion device	Open	PENDING	2036-06-15						
57546569	AU20	VISUNEX MEDICAL	2015-06-19	073)A wide field of view optica	073)Disclosed herein is an opt	Open	PENDING	2036-06-17					X	
57504886	AU20	NATIONAL RESEARCH	2015-06-08	388)Real-time inspection of au	388)A technique for automatec	Open	PENDING	2036-06-08						
57392277	AU20	LAZCATH	2015-05-25	400)Catheter system and meth	400)A catheter system for abla	Open	PENDING	2036-05-25						X
57277702	AU20	LIGHTLAB IMAGING	2015-05-17	949)Intravascular imaging syst	949)In part, the disclosure rela	Open	PENDING	2036-05-17						X
57320488	AU20	LIGHTLAB IMAGING	2015-05-17	099)Intravascular imaging syst	099)The disclosure relates, in	Open	PENDING	2036-05-17						X
32031468	EP3	CARL ZEISS	2002-08-23	Device for treating a tissue	The invention relates to a dev	Open	PENDING	2023-08-22					X	
52876132	EP3	MICHELSON	2015-02-26	Processing optical coherence t	A method of processing optica	Open	PENDING	2036-02-17		X				

Introduction | Segmentation | Database

ORDER FORM

Optical Coherence Tomography Medical Imaging – Patent Landscape Analysis 2018

Ref.:KM18001

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Name (Mr/Ms/Dr/Pr):
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Bank: Banque populaire St Laurent du Var CAP 3000 - Quartier du lac- 06700 St Laurent du Var
IBAN: FR76 1560 7000 6360 6214 5695 126
BIC/SWIFT: CCBPFRPPNCE

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2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

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2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in article 3.

2.4 The mailing is operated through electronic means either by email via the sales department. If the Product's electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

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3. PRICE, INVOICING AND PAYMENT

3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

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BIC or SWIFT code: CCBPFRPPNCE
IBAN: : FR76 1560 7000 6360 6214 5695 126

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

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4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement

4.3 In no event shall the Seller be liable for:

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b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

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5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

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6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;
- Recordings and re-transmittals over any network (including any local area network);
- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
- Posting any Product to any other online service (including bulletin boards or the Internet);
- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.