OBJECTIVE OF THE REPORT

• Understand the IP landscape for biomedical photoacoustic imaging.
• Identify key patents.
• Understand trends in biomedical photoacoustic imaging IP.
• Classify the major players in biomedical photoacoustic imaging IP and the relative strength of their patent portfolio.
• Identify new players in biomedical photoacoustic imaging IP.
• Identify IP collaboration networks between key players.

REPORT OUTLINE

• Biomedical Photoacoustic Imaging.
• Patent Landscape.
• March 2015.
• PDF & Excel file.
• €3,990 (corporate license).

KEY FEATURES OF THE REPORT

The report provides essential patent data for biomedical photoacoustic imaging including:
• Time evolution of patent publications and countries of patent filings.
• Current legal status of patents.
• Ranking of main patent applicants.
• Joint developments and IP collaboration network of main patent applicants.
• Key patents.
• Granted patents near expiration.
• Relative strength of main companies IP portfolio.
• Photoacoustic imaging IP profiles of 15 major companies with key patents, partnerships, and IP strength and strategy.

The report also provides an extensive Excel database with all patents analyzed in the study.

PHOTOACOUSTIC: A NEW TECHNOLOGICAL REVOLUTION IN MEDICAL IMAGING?

Photoacoustic imaging technologies in the biomedical domain are in full growth from an IP point of view, and have began to move in the clinical field. If Japanese companies Canon and Fujifilm are the main IP holder, the market is held by US actors: ENDRA Life Sciences, VisualSonics, Seno Medical Instruments, OptoSonics or TomoWave Laboratories.

This patent landscape focuses on photoacoustic imaging in biomedicine. Photoacoustic imaging is a safe, non-invasive, non-ionizing imaging technique. The technique offers several advantages and represents a great alternative to traditional medical imaging approaches. The innovation of photoacoustic imaging for biomedical purposes is mainly driven by the need to enhance the efficiency of the detection and diagnostic of cancer.

The photoacoustic imaging technologies involve more than 100 different applicants and more than 900 patent families related to photoacoustic imaging have been published worldwide up to January 2015. In the early 80s, the University of Arizona published the 1st patent transposing photoacoustic technology to biomedical imaging. But the technology only really emerged in 1997, especially after the publication of the patent introducing a time factor to the technology and thus allowing a three dimensional image reconstruction. Since 2010, a take off in the number of new applications is observed, indicating a strong and growing interest for the use of photoacoustic imaging techniques. Photoacoustic imaging is a very promising technique for the medical field, especially for diagnostic and treatment cancers, and offers many advantages such as safety, great resolution, easy-to-use and low cost. Thus the number of new patent applications in the domain is expected to keep rising.

Key Patent Families

Key patents have been identified based on several indicators, including family size, legal status, citations analysis and impact on photoacoustic biomedical imaging technology. If industrial applicants are the main IP holder, academic applicants hold key patents and the importance of their portfolios is significant. In particular, the NIH and the University of Texas stand out as important actors as they own strong portfolios with key technologies.
The 900+ patent families selected for this study have been manually segmented by products and applications. Products include contrast agents and imaging devices, such as handheld probes or catheter including an imaging mean while the most targeted applications are the diagnosis and treatment of cancers and vascular pathologies. Photoacoustic imaging is a very promising technique for the medical domain and several imaging devices have been developed from patented technologies included in this patent landscape. Devices for pre-clinical research are already available on the market and medical devices are currently in clinical trials.

### IMPACT OF PATENT PORTFOLIOS

The impact factor of patent portfolios and the IP blocking potential of the applicants have been analyzed. The most influent portfolios belong to **US academic applicants**. The portfolio of company **Seno Medical Intr.**, who is also present on the market, has a significant impact as well.

Our report also includes an **Excel database** containing all of the analyzed patents. This database allows for multi-criteria searches and includes patent publication number, hyperlinks to the original documents, priority date, title, abstract, patent assignees, technological segments and legal status for each member of the patent family.

### IDENTIFY KEY PLAYERS

Many American, Japanese and Chinese assignees feature among the main patent applicants. **Key players include academic and industrial actors**. In term of filing activity, **industrial applicants** are getting the upper hand, especially **Canon** and **Fujifilm**. The report provides a ranking and analysis of the relative strength of the top patent holders derived from their portfolio size, patent citations networks, countries of patents filings, current legal status of patents. Through this thorough analysis, we have identified 15+ major players, each of which is profiled in this report. Each profile includes a detailed portfolio analysis with patent activities, key patents, impact of portfolio, granted patents near expiration and IP strategies.
ASSIGNEES CITED IN THE REPORT (NON-EXHAUSTIVE)
Canon, Fujifilm, VisualSonics, Seno Medical Instruments, Volcano, Philips, Covidien, Malinckrodt, Samsung, OptoSonics, ENDRA Life Sciences, TomoWave Laboratories, NIH, University of Texas, Helmholtz Zentrum München, South China Normal University, Jiangxi Sciences & Technic Normal University, Shenzhen Institute of Advanced Technology ...

TABLE OF CONTENT

| Introduction | 3 |
| Scope of the Report | 5 |
| Key Features of the Report | 6 |
| Objectives of the Report | 8 |
| Terminology for Patent Analysis | 9 |
| Methodology | 12 |
| Patent Search Strategy | 14 |
| Assignee Mentioned in this Report | 15 |
| Introduction to Photoacoustic Imaging Patent Landscape Overview | 21 |
| Time Evolution of Patent Publications | 30 |
| Countries of Patent Filings | 31 |
| Time Evolution by Country of Filing | 32 |
| Current Legal Status of Patents | 33 |
| Main Industrial Patent Applicants Ranking | 34 |
| Main Academic Patent Applicants Ranking | 35 |
| Time Evolution of Patent Applicants | 36 |
| Countries of Filing for Main Patent Applicants | 37 |
| Mapping of Main Current IP Holders | 38 |
| Mapping of Main Current IP Applicants | 39 |
| Main IPC Classes | 40 |
| Time Evolution by IPC | 41 |
| Matrix Applicants / Main IPC | 42 |
| Patented Technology by Products | 43 |
| Patented Technology by Applications | 44 |
| Summary of Applicant’s Patent Portfolio | 45 |
| Leadership of Patent Applicants | 47 |
| Degree of Specialization in Photoacoustic imaging | 49 |
| Impact Factor of Patent Portfolios | 50 |
| IP Blocking Potential of Applicants | 52 |
| Patent Applicant IP Network | 53 |
| Key Patent Families | 55 |
| Granted Patents Near Expiration | 57 |
| Potential Future Plaintiffs | 58 |
| Summary of Key Players | 59 |
| Canon | 60 |
| Fujifilm | 62 |
| Fujifilm VisualSonics | 64 |
| Seno Medical Instruments | 65 |
| Philips | 68 |
| Volcano | 70 |
| Covidien | 72 |
| Malinckrodt Pharmaceuticals | 74 |
| Samsung | 76 |
| ENDRA Life Sciences | 78 |
| TomoWave Laboratories | 80 |
| National Institutes of Health | 82 |
| University of Texas | 84 |
| Helmholtz Zentrum München | 86 |
| South China Normal University | 88 |
| Jiangxi Sciences & Technic Normal University | 90 |
| Shenzhen Institute of Advanced Technology | 92 |
| Conclusions | 94 |
| Annexes | 100 |
| Methodology for Key Patent Identification | 101 |
| KNOWMADE Company presentation | 103 |
| Contact | 111 |

AUTHORS

Dr. Coralie Le Greneur
Coralie works for Knowmade in the field of Biotechnology and Life Sciences. She holds a PhD in Molecular Biology from the University of Nice Sophia-Antipolis (France). She also holds the International Industrial Studies Diploma in Patents from the CEIPI, Strasbourg (France).

Dr. Brice Sagot
Brice is COO and co-founder of Knowmade. He is leading the Biotechnology and Life Sciences department. He holds a PhD in molecular biology from the University of Nice Sophia-Antipolis, France.

ABOUT KNOWMADE

Knowmade is a Patent, Technology and Strategy consulting company involved in Microelectronics, Nanotechnology, Biotechnology and Life Sciences. We provide Patent Search, Patent Landscape, Patent Analysis, Scientific Landscape, State of the Art, Technology Scouting, Technology Tracking, Alerts and Updates. Our service offer consists of standard reports, custom studies & on-demand tracking, strategy consulting and training. We combine information search services, scientific expertise, powerful analytics and visualization tools, and proprietary methodologies for analyzing patents and scientific information. Knowmade supports research laboratories, industrial companies and investors in their business development.
ORDER FORM
Biomedical Photoacoustic Imaging Patent Landscape
2015

SHIP TO
Name (Mr/Ms/Dr/Pr):
________________________________________
Job Title:
________________________________________
Company:
________________________________________
Address:
________________________________________
City:
________________________________________
State:
________________________________________
Postcode/Zip:
________________________________________
Country:
________________________________________
VAT ID Number for EU members:
________________________________________
Tel:
________________________________________
Email:
________________________________________
Date:
________________________________________

PAYMENT METHODS
Check
To pay your invoice using a check, please mail your check to the following address:
KnowMade S.A.R.L.
2405 route des Dolines, BP 65
06902 Valbonne Sophia Antipolis
FRANCE

Money Transfer
To pay your invoice using a bank money wire transfer please contact your bank to complete this process. Here is the information that you will need to submit the payment:
Payee: KnowMade S.A.R.L.
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

Paypal
In order to pay your invoice via PAYPAL, you must first register at www.paypal.com. Then you can send money to the KnowMade S.A.R.L. by entering our E-mail address contact@knowmade.fr as the recipient and entering the invoice amount.

RETURN ORDER BY
E-mail: contact@knowmade.fr
Mail: KnowMade S.A.R.L. 2405 route des Dolines CS 10065, BP 65
06902 Sophia Antipolis FRANCE

CONTACT
E-mail: contact@knowmade.fr

PRODUCT ORDER
☐ €2,990 – Single user license*
☐ €3,990 – Corporate license
For price in dollars, please use the day’s exchange rate. For French customer, add 20% for VAT.

All reports are delivered electronically in pdf format at payment reception.

*Single user license means only one person at the company can use the report. Please be aware that our publication will be watermarked on each page with the name of the recipient and of the organization (the name mentioned on the PO). This watermark will also mention that the report sharing is not allowed.

I hereby accept Knowmade’s Terms and Conditions of Sale
Signature:
TERMS AND CONDITIONS OF SALES

Definitions

“Acceptance”: Action by which the Buyer accepts the terms and conditions of sale in their entirety. It is done by signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”.

“Buyer”: Any business user (i.e. any person acting in the course of its business activities, for its business needs) entering into the following general conditions to the exclusion of consumers acting in their personal interests.

“Contracting Parties” or “Parties”: The Seller on the one hand and the Buyer on the other hand.

“Intellectual Property Rights” (“IPR”) means any rights held by the Seller in its Products, including any patents, trademarks, registered models, designs, copyrights, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property rights or similar in any part of the world, notwithstanding the fact that they have been registered or not and including any pending registration of one of the above mentioned rights.

“License”: For the reports and databases, 2 different licenses are proposed. The buyer has to choose one license:
1. Single user license: a single individual at the company can use the report.
2. Corporate license: the report can be used by unlimited users within the company. Subsidiaries are not included.

“Products”: Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

“Seller”: Based in Sophia Antipolis (France headquarters), Knowmade is a technology intelligence company specialized in the research and analysis of scientific and technical information. We provide patent landscapes and scientific state of the art with high added value to businesses and research laboratories. Our intelligence digests play a key role to define your innovation and development strategy.

1. Scope

1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. ANY ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS IN ANY OTHER DOCUMENTS ISSUED BY THE BUYER AT ANY TIME ARE HEREBY OBJECTED TO BY THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.

1.2 This agreement becomes valid and enforceable between the Contracting Parties after clear and non-equivalent consent by any duly authorized person representing the Buyer. For these purposes, the Buyer accepts these conditions of sales when signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”. This results in acceptance by the Buyer.

1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7 days] from the date of order, to be sent either by email or to the Buyer’s address. In the absence of any confirmation in writing, orders shall be deemed to have been accepted.

2. Mailing of the Products

2.1 Products are sent by email to the Buyer:
- within [1] month from the order for Products already released; or
- within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.

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

The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including in cases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.

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.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

2.6 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer’s risk.

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.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmade, PayPal or by electronic transfer to the following account:
Banque populaire St Laurent du Var CAP 3000- Quartier du lac- 06700 St Laurent du Var
BIC or SWIFT code: CCBBPPFRPNE
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 receipt 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.

4. Liabilities

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. 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.

4.5 In no event shall the Seller be liable for:
   a) damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller’s website or the Products, or any information provided on the website, or in the Products;
   b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.6 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.

4.7 The Seller shall be liable if, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.8 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.9 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.10 The Seller does not make any warranties, express or implied, including, without limitation, those of saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

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.

6. Protection of the Seller’s IPR

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 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.