From Technologies to IP Business Intelligence

Hybrid Bonding

Patent Landscape Analysis

November 2019

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Patent & Technology Intelligence

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Position on the supply chain
- *Hybrid bonding process*
- *Devices using hybrid bonding technology*

Applications:
- *CMOS image sensor (CIS)*
- *Memory*
- *MEMS*
- *LED*

KEY PATENTS 40

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For each player: patent portfolio overview, key patents, and recent patenting activity
- Main IP players
  - *TSMC*
  - *Xperi*
- IP Newcomers
  - *YMTC*

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INTRODUCTION
Hybrid bonding process flow

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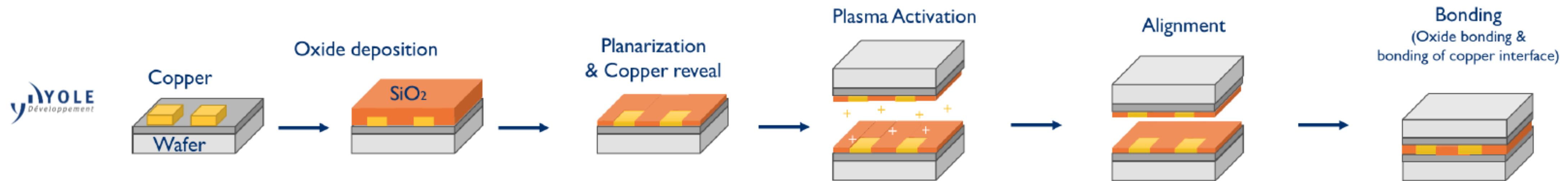
For the context of this patent investigation, **hybrid bonding** is defined as a **permanent bond** that combines a **dielectric bond with embedded metal** to form interconnections. It's become known industry-wide as **direct bond interconnect**, or DBI from Xperi/Invensas.

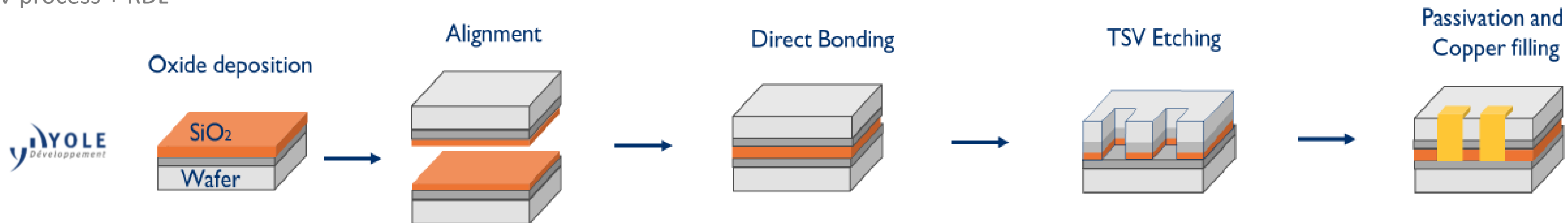
Hybrid bonding

- Copper pads on both wafers (upper & lower ones)
- Oxide deposition & planarization (very low surface roughness is required ~1nm)
- Plasma activation + alignment (able to go under 1µm of pitch alignment using a stepper) + Room temperature bonding followed by post-alignment and an annealing cycle



Direct bonding + TSV

- Oxide/oxide permanent bonding
- Via Last TSV process + RDL



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SCOPE OF THE REPORT

SAMPLE

- This report provides a detailed picture of the patent landscape for **Hybrid Bonding**.
- This report covers **patents published worldwide** up to **September 2019**. We have selected and analyzed more than **1,005 patents and patent applications** grouped in more than **290 patent families** relevant to the scope of this report.

	Selected patents		
Example	**Relevant**	**Related**	**Excluded**
Patents related to hybrid bonding process	X		
Patents related to devices using hybrid bonding	X		
Patents describing a specific embodiment where hybrid bonding is used		X	
Patents related to ZiBond™ or other dielectric/dielectric bonding			X
Patents related to metal/metal direct bonding			X
Patents related to any bonding process using solder balls, etc.			X

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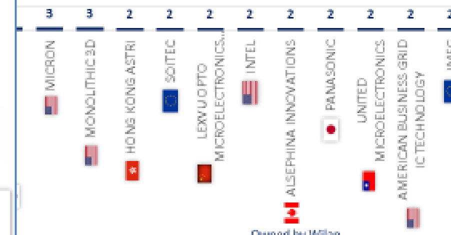
Understanding the main trends

Who, When and where?

SAMPLE

IP LANDSCAPE OVERVIEW

Main patent assignee for hybrid bonding technology



…n its competitor's.

…elopment of **memoy** or **image sensor** devices. However, the … Indeed, today only **STMicroelectronics** shows a significant … …e **Xperi, WiLAN** or **Intellectual Ventures**.

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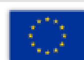
IP LANDSCAPE OVERVIEW

Geographic map of patent applications related to hybrid bonding



Europe

EP Granted	
CEA	9
TSMC	6
STMICROELECTRONICS	4
XPERI	2

EP Pending	
TSMC	24
CEA	5
SMIC	4
XPERI	3

South Korea

KR Granted	
TSMC	29
XPERI	4
SONY	2
CANON	1
STMICROELECTRONICS	1
CEA	1
	1
	1
…TIONAL UNIVERSITY …Y FOUNDATION	1

KR Pending	
TSMC	19
SAMSUNG ELECTRONICS	6
SONY	5
XPERI	4
CEA	2
CANON	1
RENESAS ELECTRONICS	1
RAYTHEON	1
APPLE	1

Japan

JP Granted	
SONY	10
XPERI	7
TSMC	6
CANON	5
CEA	3
PANASONIC	2

JP Pending	
SONY	3
XPERI	2
RENESAS ELECTRONICS	2
CANON	1
CEA	1
RAYTHEON	1
QUALCOMM	1
TOSHIBA	1

China

CN Pending	
…MC	45
…MTC	22
…ONY	6
…ANGHAI IC R & D CENTER	5
…MC	4
…MINIVISION …CHNOLOGIES	4
…ANON	3

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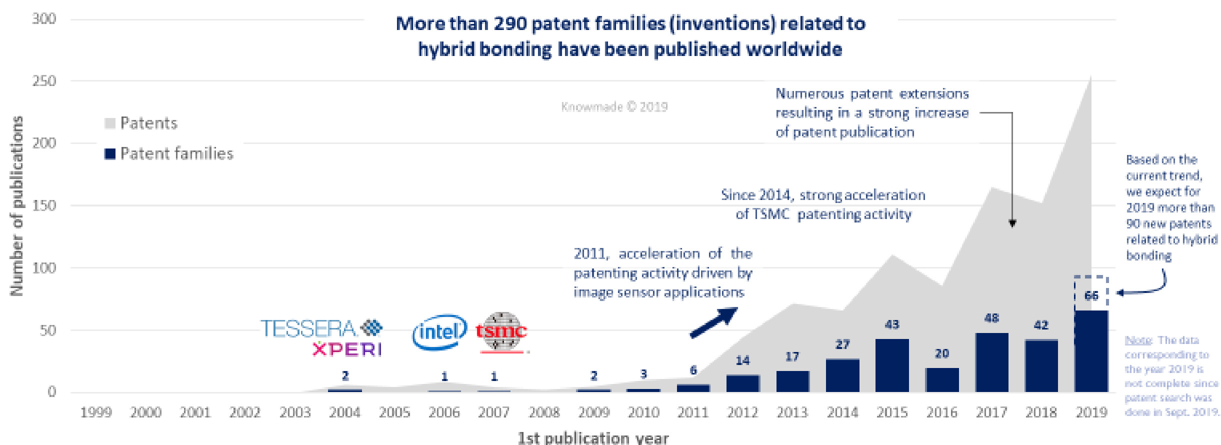
IP LANDSCAPE OVERVIEW

IP dynamics for hybrid bonding technology



The **IP landscape** related to **hybrid bonding** is still **small and young**. Indeed, despite some early patents published in 2004, the patenting activity really **took off in 2010**. This growth was first driven by **Tessera** (now **Xperi**).
Since 2010, the patenting activity has progressively accelerated but the number of patent families (inventions) remains small. However, the gap between the number of patents (grey color on the graph) and the number of patent family (blue bar graph) is increasing. This trend is the result of the **recent development of IP player's patent portfolios** which have started to **extend their priority patents** in foreign countries in order to assert their inventions in all key countries.

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Comparison of IP players

Portfolios analysis and ranking: who has the strongest IP position and why?

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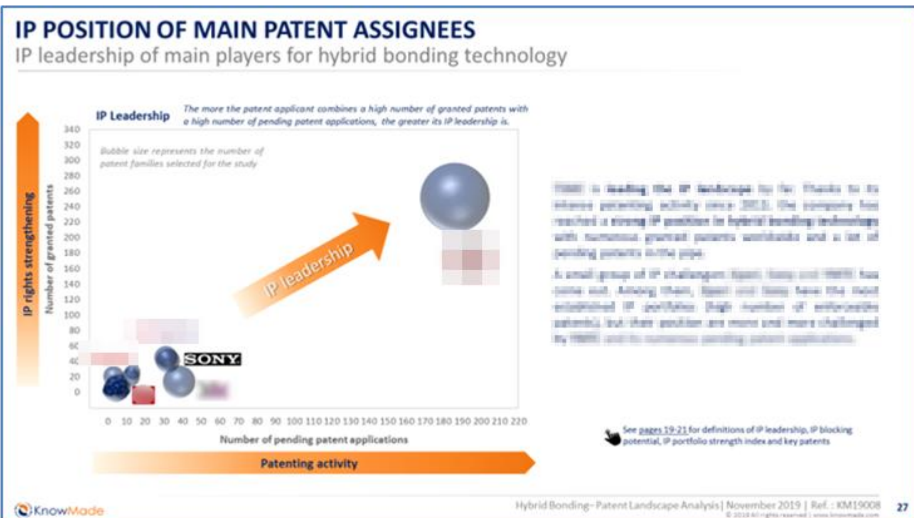
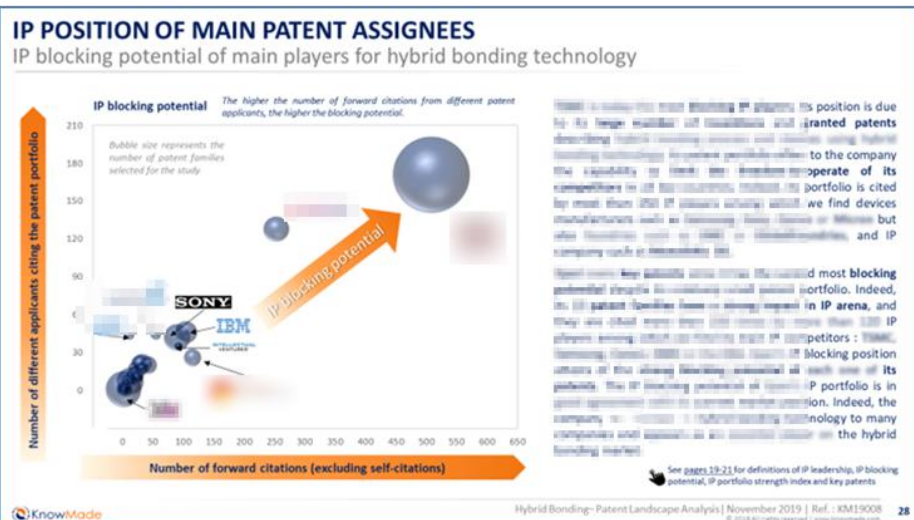
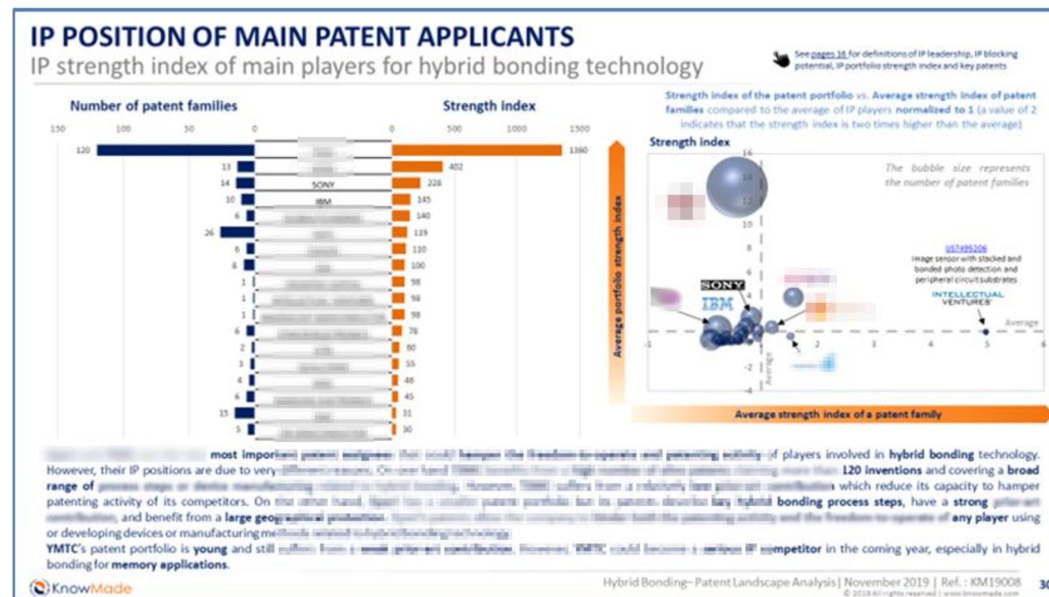




IP leadership

Blocking potential



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Identify you competitors and their developments

Corpus segmentation by applications

SAMPLE

PATENT SEGMENTATION

Main patent assignes by type of patents and applications

	Image sensor	Stacked Memory	Memory on logic	LED	MEMS
	47 inventions	69 inventions	51 inventions	3 inventions	33 inventions

PATENT SEGMENTATION

Patent claiming device using hybrid bonding technology

IP Leadership

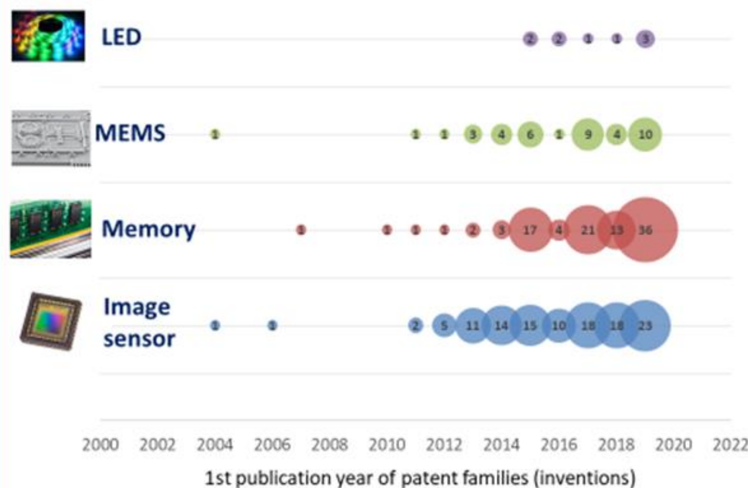
The more the patent applicant combines a high number of granted patents with a high number of pending patent applications, the greater its IP leadership is.

See pages 16 for definitions of IP leadership, IP blocking potential, IP portfolio strength index and key patents

PATENT SEGMENTATION

Time evolution of patent publications by application mentioned in patents

Hybrid bonding related patenting activity by application



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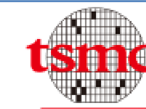
Main IP players portfolio analysis

What are their IP strength, weaknesses, key patents and recent development?

SAMPLE

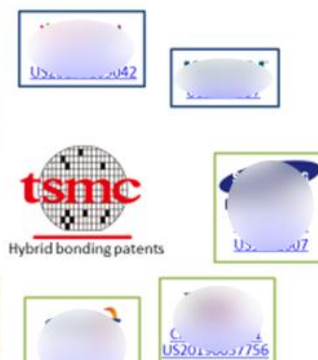
KEY PATENTS

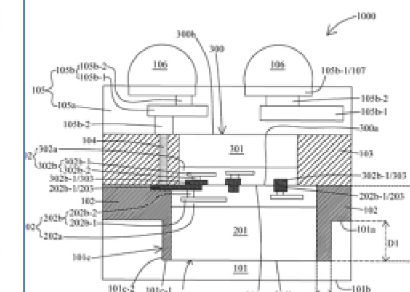
TSMC



IP PROFILE

TSMC : licensing activity





IP PROFILE

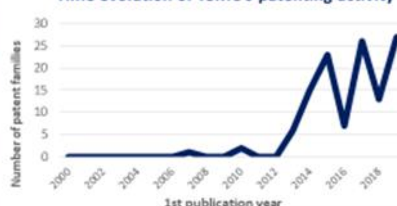
TSMC : patent portfolio overview

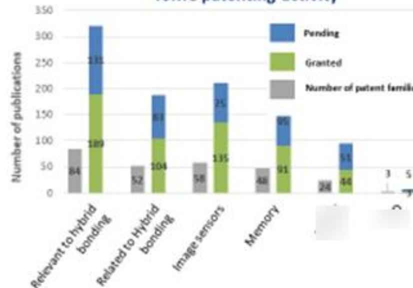
TSMC is the of the last 6 years in the **hybrid bonding** related patent landscape. The company has developed a large patent portfolio that includes **hybrid bonding processes** and **devices using hybrid bonding technology**. TSMC benefits from a high claiming more than **inventions** and covering However, the company suffers from a relatively **low** which reduce its capacity to

With more than 120 inventions and alive patents worldwide, **TSMC** is today the thanks to IP portfolio covering not only **key bonding** but also for different applications (CIS, Memory, MEMS, etc.). This can be explained by **TSMC** market position. Indeed, today all the bonding solutions for 3D stacking.

The **main difference** between and **TSMC**'s one is the of each one of their patents. Indeed, at a each of TSMC's patent has a

According to our knowledge, TSMC will probably release its first product (memory) using hybrid bonding process in 2020.





* Each characteristic has been normalized to 1. 1 being the average value that for the top 30 main IP players

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Patent database

Excel file containing all the patents analyzed in this report with corpus segmentation

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

Hybrid Bonding - November 2019

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Questel unique family ID (FAN)	Publication numbers	Title	Abstract	Earliest application date	Earliest publication date	Expected expiry dates	Current assignees	Inventors	Legal status (Pending, Granted, Revoked, Expired, Lapsed)	Original document	Hybrid Bonding process	Devices using hybrid bonding	Image sensor	Memory	MEMS	LED
86379451	US20190326252	(US20190326252) Dbi to si bonding for simplified handle wafer	Devices and techniques include process steps for preparing various microelectronic components for bonding, such as for	2019-04-17	2019-10-24	2039-04-17	INVENSAS BONDING TECHNOLOGIES ([US])	MANDALAPU CHANDRASEKHAR ([US])	PENDING	Open						
86379451	WO2019/204532	(WO2019204532) Dbi to si bonding for simplified handle wafer	Devices and techniques include process steps for preparing various microelectronic components for bonding, such as for	2019-04-17	2019-10-24	2021-10-20	INVENSAS BONDING TECHNOLOGIES ([US])	MANDALAPU CHANDRASEKHAR ([US])	PENDING	Open						
86304012	US20190319007	(US20190319007) Low temperature bonded structures	Devices and techniques including process steps make use of recesses in conductive interconnect structures to form	2019-03-25	2019-10-17	2039-03-25	INVENSAS BONDING TECHNOLOGIES	UZOH CYPRIAN EMEKA ([US])	PENDING	Open						
86304012	WO2019/199445	(WO2019199445) Low temperature bonded structures	Devices and techniques including process steps make use of recesses in conductive interconnect structures to form	2019-03-25	2019-10-17	2021-10-11	INVENSAS BONDING TECHNOLOGIES ([US])	UZOH CYPRIAN EMEKA ([US])	PENDING	Open						
86017594	CN110249427	(CN110249427) Three-dimensional memory device having an embedded	There is disclosed having an embedded dynamic random access memory (DRAM) of a three-dimensional (3 D) for	2019-04-30	2019-09-17	2039-04-30	YANGTZE MEMORY TECHNOLOGIES ([CN])	LIU JUN	PENDING	Open		X		X		
85913273	US20190273109	(US20190273109) Semiconductor device, fabrication method for a	Disclosed herein is a semiconductor device, including: a first substrate including a first electrode, and a first insulating film	2019-05-13	2019-09-05	2032-06-26	SONY ([JP])	AOYAGI KENICHI ([JP])	PENDING	Open		X	X			
85894425	US20190273108	(US20190273108) Solid-state imaging device and method for manufacturing the	A hybrid-bonding-type ... that prevents mo...	[illegible]	2019-09-05	2039-02-19	RENESAS ELECTRONICS ([JP])	IIZUKA KOJI ([JP])	PENDING	Open		X	X			
85894425	JP2019153675	(JP2019153675) Solid-state imaging device and a manufacturing method	A hybrid-bonding-type solid-state imaging device is provided that prevents moisture from entering through the bonded	2018-03-02	2019-09-05	2038-03-02	RENESAS ELECTRONICS	IIZUKA KOJI	PENDING	Open		X	X			
85851827	CN110192269	Three-dimensional ...	[illegible]	[illegible]	[illegible]	[illegible]	YANGTZE MEMORY TECHNOLOGIES ([CN])	LIU JUN	PENDING	Open		X		X		
85834472	US10403577	(US10403577) Dielets on flexible and stretchable packaging for	Dielets on flexible and stretchable packaging for microelectronics are pro...	[illegible]	2019-09-03	2038-05-03	INVENSAS	HUANG SHAOWU ([US]) DELACRUZ JAVIER A ([US])	GRANTED	Open					X	
85834472	US20190341350	(US20190341350) Dielets on flexible and stretchable packaging for	Dielets on flexible and stretchable packaging for microelectronics are provided. Configurations of flexible,	2018-05-03	2019-09-03	2038-05-03	INVENSAS ([US])	Huang Shaowu ([US]) Delacruz Javier A. ([US])	PENDING	Open	X				X	
85827647	US20190268555	(US20190268555) Cmos image sensor clamping method with divided bit lines	[illegible]	[illegible]	[illegible]	2038-12-17	OMNIVISION TECHNOLOGIES	EBIHARA HIROAKI ([US])	PENDING	Open		X	X			
85827647	CN110191295	(CN110191295) CMOS image sensor using the divided clamp method of the	An image sensor includes a pixel array including a plurality of pixels. A bit line is coupled to a column of pixels of the pixel	2018-12-17	2019-08-29	2039-02-22	OMNIVISION TECHNOLOGIES ([US])	EBIHARA, HIROAKI	PENDING	Open		X	X			
85827645	US20190268556	(US20190268556) Cmos image sensor with divided bit lines	pixels. A bit line coupled to a column of pixels is separated in	2018-12-17	2019-08-29	2038-12-17	OMNIVISION TECHNOLOGIES	WANG RUI ([US])	PENDING	Open		X	X			
85827645	CN110191296	(CN110191296) CMOS image sensor having a divided bit line	An image sensor includes a pixel array including a plurality of pixels. A bit line coupled to a column of pixels is separated in	2018-12-17	2019-08-29	2039-02-22	OMNIVISION TECHNOLOGIES ([US])	WANG RUI	PENDING	Open		X	X			
85827645	TW201937716	(TW201937716) Cmos image sensor with divided bit lines	An image sensor includes a pixel array including a plurality of pixels. A bit line coupled to a pixel row is divided into a	2018-12-17	2019-08-29	2039-02-21	OMNIVISION TECHNOLOGIES	WANG RUI	PENDING	Open		X	X			
85682145	US20190252375	(US20190252375) Back biasing of FD-SOI circuit blocks	A microelectronic circuit structure comprises a stack of bonded layers comprising a bottom layer and at least one	2018-02-09	2019-08-15	2038-02-09	XCELSIS	FISCH DAVID EDWARD	PENDING	Open	X			X		
85682139	US20190252353	(US20190252353) Face-to-face three-dimensional integrated circuit of simplified structure	An integrated circuit including a first chip including a stack of a substrate, of an active layer and of interconnect layers; a	2018-02-14	2019-08-15	2039-02-06	CEA - COMMISSARIAT A L ENERGIE ATOMIQUE & AUX ENERGIES ALTERNATIVES ([FR])	LATTARD DIDIER ([FR]) THURIES SEBASTIEN ([FR])	PENDING	Open	X			X		

Patent information

Dates and numbers of priority/application/publication/grant

Title, abstract, claims

Patent applicants, current assignees, inventors

Current legal status of patents (granted, pending, expired, etc.)

Segments

Hybrid bonding process, Device using hybrid bonding, Image sensor, Memory, MEMS, LED, etc.

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ORDER FORM

Hybrid bonding

Patent Landscape Analysis – November 2019

Ref.:KM19008

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:
____

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2405 route des Dolines
06902 Valbonne Sophia Antipolis
FRANCE

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Bank: Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var, France
IBAN: FR76 1460 7003 6360 6214 5695 139
BIC/SWIFT: CCBPFRPPMAR

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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.

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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.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmade, PayPal or by electronic transfer to the following account:

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BIC or SWIFT code: CCBPFRPPMAR

IBAN: : FR76 1460 7003 6360 6214 5695 139

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.

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.

4.2 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

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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.

4.4 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.

4.5 All the Products that the Seller sells may, 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.

4.6 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.

4.7 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.

4.8 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 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.

Knowmade Company

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WHAT WE DO

Knowmade helps customers to understand

the **competitive landscape**, follow **technology trends**, and find out **opportunities** and **threats** in terms of **technology** and **patents**.

- Interpreting the **competitive landscape** and **technology developments** throughout **patents** and **scientific information**.
- Turning **patents** and **scientific information** into **business intelligence tools** that give you the capability to
  - Understand your **competitive environment**
  - Be ahead of **technology trends**
  - Identify patent & technology **opportunities**
  - Assess patent & technology **risks**
  - Define your **IP** and **R&D strategy**
  - Monetize your **technologies** and know-how
  - Defend your **business**
- Strong **technology expertise** with an in-depth **knowledge of patents** and **scientific information**.
- Highly **specialized** analysts in the following sectors:

Electronics, **Photonics** and **Wireless communications**

Compound semiconductors, Power electronics, Batteries, Memories, RF devices & technologies, Wireless communications, Solid-state lighting & display, Photonics, MEMS, Sensors and Actuators, Semiconductor manufacturing and Advanced packaging.

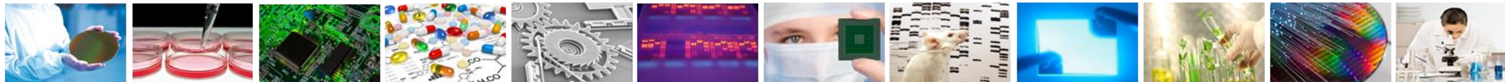
Life Sciences, **Healthcare** and **Agri-Food**

Medical devices, Medical imaging, Microfluidics, Biotechnology, Pharmaceutics, Food-processing

Patents
Technologies
Prior art
Scientific findings
Opportunities
Partners
Competitors
Newcomers
M&A targets

Patent landscape analysis
Scientific review
IP portfolio assessment
Patent valuation
Freedom-to-operate analysis
Litigation & licensing support
Patents linked to products
Technology scouting
Technology trends
Competitive IP landscape
Market trends
Reverse engineering

Make strategic decisions
Sustain competitive advantages
Speed R&D and enhance innovation process
Align R&D and IP with key business objectives
Strengthen IP portfolio and acquire technologies
Anticipate risks and defend core businesses
Explore new opportunities and monetize IP



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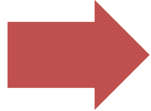
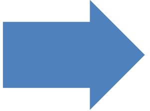
OUR ADDED VALUE

Patent Search



- ✓ **Strong technical expertise of our analysts with PhD degree**
  - Comprehensive search queries and keywords
  - Manual selection of relevant and related patents
  - Manual segmentation by technology & application

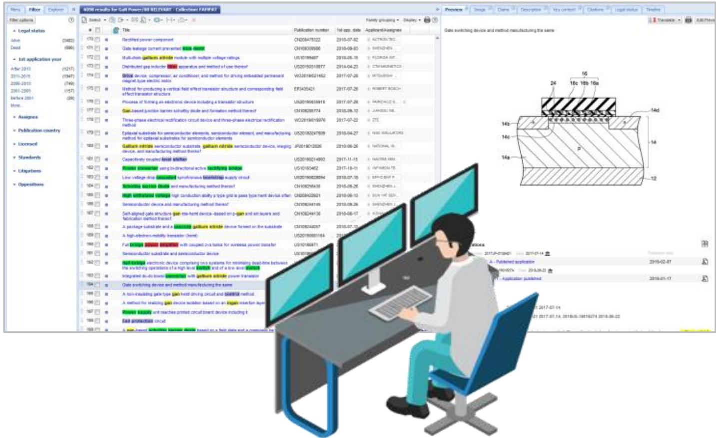
Analytics

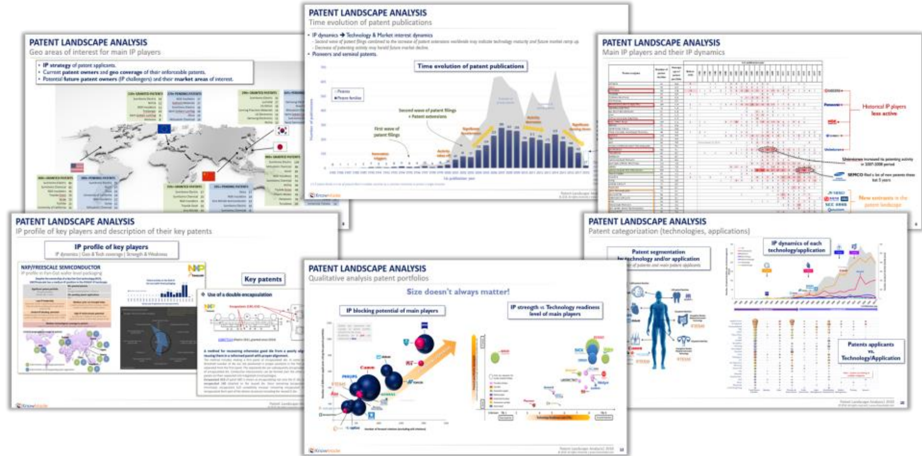


- ✓ **State of the art statistical tools**
- ✓ **Innovative methodologies to deliver relevant IP analysis**
- ✓ **Business oriented data representation and graphics**

Results Analysis

- ✓ **Technical expertise**
  - Highly specialized analysts in your field
  - Benefit from knowledge capitalization
- ✓ **In-depth IP analysis combined with market data and reverse engineering ***
- ✓ **Customer support**





*** Our partners**

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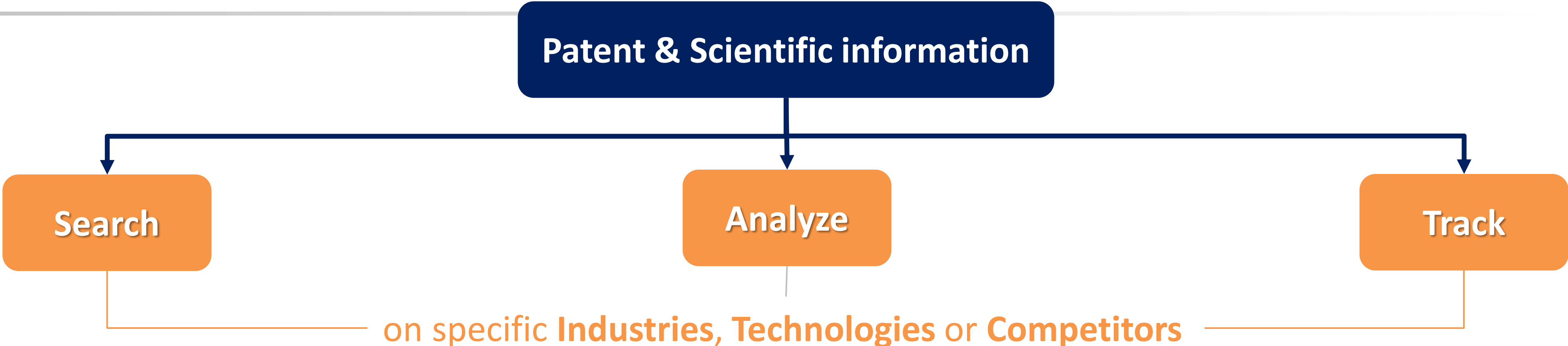
KNOWMADE ACTIVITIES



Prior-art search

Is my invention novel?

Technology scouting

Are there patents or technologies to acquire? … that could be drawn on to improve R&D?

Patent landscape analysis

Competitive & technology landscape analysis through patents: Who? What? Where? Since when? With who?

Freedom-to-operate

Am I free to sell my product without infringing third-parties IP rights?

Evidence of use (litigation/licensing)

Make the link between patents and product features

Patent valuation

What are the most valuable patents and what is their financial value?

Patent monitoring service

Monitor the IP activity: new applications, new granted patents, patents newly expired

Scientific watch

Monitor the Scientific activity

Competitor watch

Monitor the competitors R&D activities

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