

Hybrid Bonding

Patent Landscape Analysis – August 2024

Who are the key players and newcomers in the global IP race for the most advanced bonding technology shaping the future of semiconductor packaging?

REPORT OUTLINE

- Hybrid Bonding
- Patent Landscape Analysis
- August 2024
- PDF >70 slides
- Excel file >1,600 patent families
- Reference: KM24003
- 4,990 EUR for a multi-user license



KEY FEATURES

- **Global patenting trends**, including time evolution of patent publications, countries of patent filings, etc.
- **Main patent assignees and IP newcomers** in the different segments.
- Key players' **IP position** and the relative **strength** of their patent portfolio.
- Patents categorized by **type of invention** (manufacturing methods, equipment, semiconductor structures and devices) and **targeted applications** (image sensors, 2.5D/3D IC, 3D-stacked memories, photonics, etc.)
- **IP profile of key players** (patent portfolio overview, technical coverage, geographical coverage, key patents, recent IP activity, etc.)
- **Excel database** containing all patents analyzed in the report, including **patent segmentations** and hyperlinks to an **updated online database**, along with the **complete data by assignee** from the statistical analyses.

RELATED REPORTS & MONITORS

- [Advanced Semiconductor Packaging – Patent Monitor \(subscription\)](#)
- [Hybrid Bonding – Patent Landscape 2019](#)

Hybrid bonding has become a key enabler of advanced packaging

Hybrid bonding combines dielectric-to-dielectric and metal-to-metal bonds to interconnect wafer-to-wafer, die-to-wafer, or die-to-die without the need for solder or other adhesives. This bonding technology is used for the vertical stacking of multiple chips, enabling 3D heterogeneous integration and interoperability of different types of chips with various functions (e.g., logic, memory, analog, sensors) within a single package. **Hybrid bonding** enables finer pitch (<10µm, or even <1µm) with significant benefits for interconnect density and device performance. The direct metal-to-metal contact facilitates efficient heat dissipation and reduces the parasitic delay. The dielectric insulates each metal pad so that there is no signal interference between the pads.

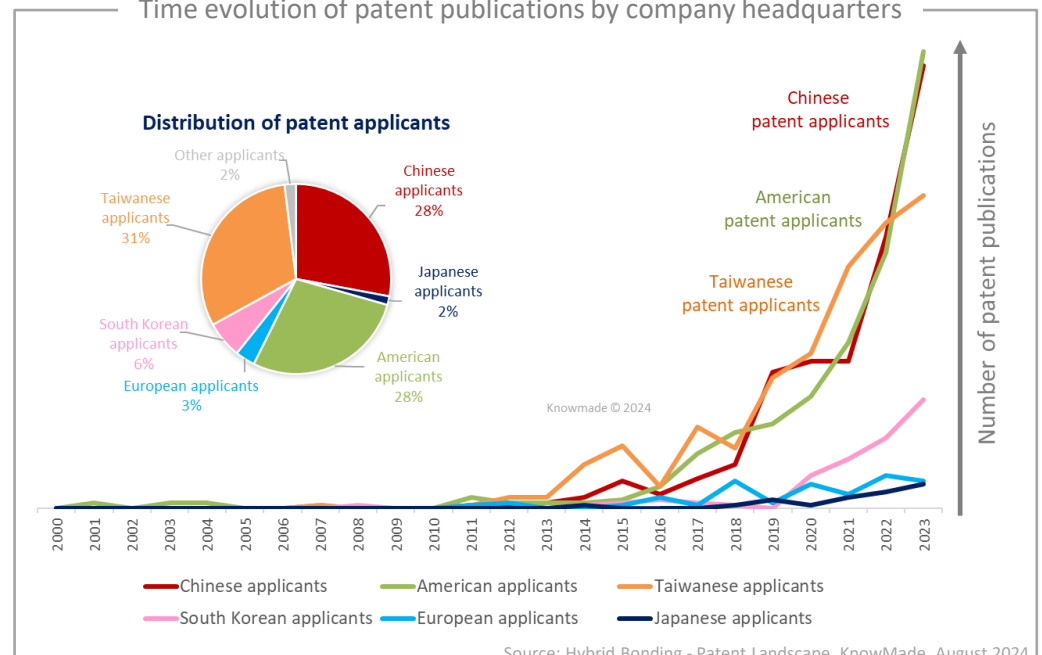
Hybrid bonding technology emerged in 2005 with the introduction of **Ziptronix's** direct bond interconnect (DBI®) technology. In 2015, **Tessera** (now **Adeia**) acquired **Ziptronix**, and DBI® technology entered the market in 2016 through Sony's CMOS image sensor (CIS) used in Samsung's Galaxy S7 mobile phone. Since then, **hybrid bonding** technology has been explored for various applications, including memory, logic, RF, and photonics, and it is now being adopted by more companies across the semiconductor industry.

Over the past five years, **hybrid bonding** technology has become a key enabler of advanced semiconductor packaging, leading to a strong increase in patenting activity and a significant evolution of the competitive intellectual property (IP) landscape. Major patent owners have strengthened their IP positions in the US, China, and Europe, while various new players have entered the patent landscape. It is now crucial for companies operating in the semiconductor packaging industry to closely examine hybrid bonding technology from an IP perspective.

In this context, **Knowmade is releasing a new patent landscape report** focusing on the hybrid bonding process and semiconductor devices made using hybrid bonding interconnects. Over **5,800 patents** from more than **1,600 patent families** (inventions) have been selected. This report aims to provide insights into current IP activities, the positions of key IP players, the applications they target in their patents, and how their patent portfolios can support their market strategies.

Hybrid Bonding Patent Landscape

Time evolution of patent publications by company headquarters



Understanding the main trends, the key players' IP position and IP strategy

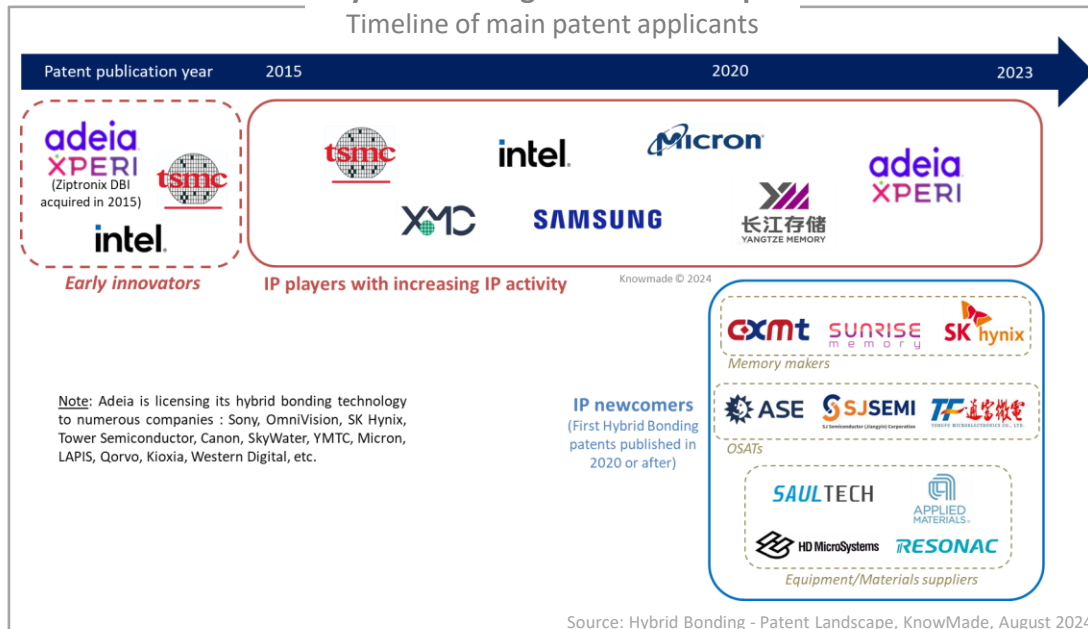
Through patent analysis, we describe the position of IP players, unveil their strategies to strengthen their IP portfolio, highlight their capability to limit the patenting activity and freedom-to-operate of other firms, identify promising new players, and forecast what would be the future IP leaders. IP competition analysis should reflect the vision of players with a strategy to enter and develop their business in the **advanced semiconductor packaging** market. In this report, we provide a comprehensive overview of the competitive IP landscape and latest technological developments related to **hybrid bonding** technology. The report covers **IP dynamics** and **key trends** in terms of patents applications, patent assignees, filing countries, patented technologies, and targeted applications. It also identifies the **IP leaders**, most **active patent applicants**, and sheds light on **under-the-radar companies and new players** in this field.

Invention type, targeted applications, and key patents

The patents have been categorized according to the **type of claimed invention** (hybrid bonding manufacturing methods and interface engineering, equipment for hybrid bonding technology, hybrid bonded semiconductor structures or devices) and the **applications mentioned in the patents** (image sensors, 2.5D/3D ICs, 3D-stacked memories, photonics, MEMS, RF, etc.). The 2.5D/3D IC segment is currently driving patenting activity, while patents related to other applications, such as photonics, microLED, MEMS, and RF, have surged.

Hybrid Bonding Patent Landscape

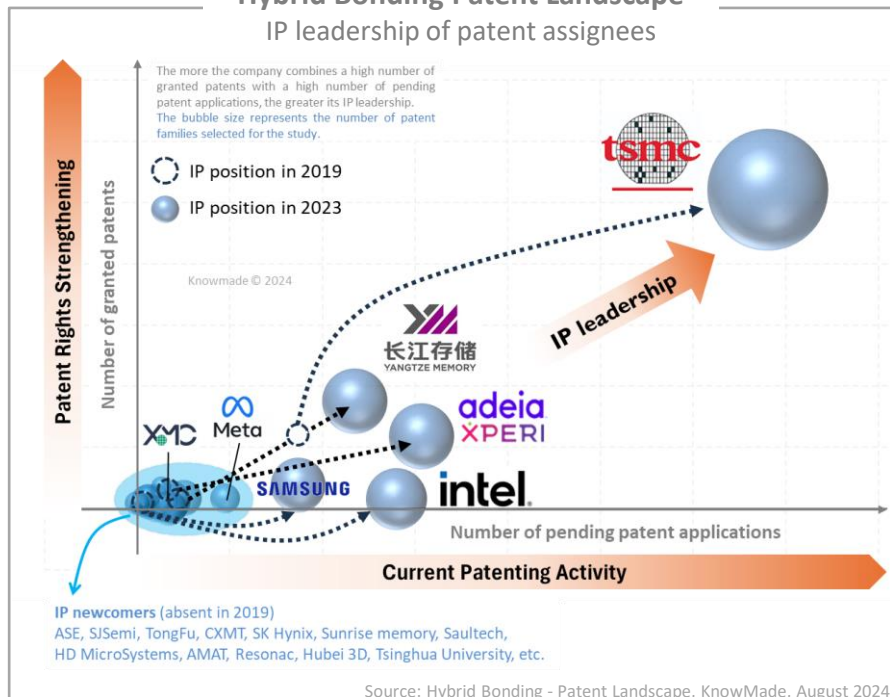
Timeline of main patent applicants



Among the 1,600+ inventions studied in this report, we have identified **over 280 key patents** that are most critical in terms of prior art, IP risks, and technology. The report provides their patent owners and the technical/application segments to which they belong.

Hybrid Bonding Patent Landscape

IP leadership of patent assignees



A dynamic IP landscape: evolution of leading players' positions and entry of new patent applicants

TSMC, Adeia, YMTC, Intel, and Samsung are leading the **patent landscape**, increasing patenting activity, and expanding invention protection in key countries. As pioneer and owner of DBI® technology, **Adeia** has adopted an aggressive strategy to assert its patents and license its hybrid bonding IP portfolio to various semiconductor companies, including **Sony, YMTC, Micron, and Kioxia**. Despite its strong IP position, other players have been developing their own hybrid bonding patent portfolios. In recent years, more memory makers have become involved in the IP landscape (**CXMT, SK Hynix, Sunrise Memory**), and OSATs and equipment/materials suppliers have entered the IP arena (**ASE, TongFu, SJSemi, Applied Materials, Saultech, HD MicroSystems**). In this report, we provide an overview of the IP portfolios held by key players and describe **key patents** and **recent IP activities**. Additionally, we highlight the main **IP collaborations** (co-owned patents, IP transfers, licensing agreements) and **patent litigations**.

Useful Excel patent database

This report includes an extensive **Excel database with** all patents analyzed in this study, including **patent information** (numbers, dates, assignees, title, abstract, etc.) and **hyperlinks to an updated online database** (original documents, legal status, etc.), **affiliation segments** (manufacturing methods, equipment, semiconductor devices, image sensors, 2.5D/3D IC, 3D-stacked memory, etc.), and **key patents**. Additionally, the Excel file comprises the **complete data by assignee** from the statistical analyses, including the number of patent families, timeline of patenting activity, number of granted patents and pending patent applications, and geographical coverage of patent portfolio.



Companies mentioned in the report (non-exhaustive)

TSMC, YMTC, Xperi/Adeia, Intel, Samsung, XMC, Micron, Tongfu Microelectronics, ASE, Meta (Facebook), Nanya Technology, CXMT, Huawei, Onsemi, OmniVision, AMD, ICLeague Technology, Monolithic 3D, UMC/Wavetek, Qualcomm, SJSemi, Saultech, SK Hynix, Tsinghua University, CEA, imec, Galaxycore Microelectronics, Apple, EVG, HD MicroSystems, NCAP, STMicroelectronics, Applied Materials, Resonac, GlobalFoundries, SunRise Memory, Alibaba Group, AP Memory, SMIC, Powerchip Semiconductor Manufacturing, MICLEDI, AMS-Osram, SmartSens Technology, Shenzhen Aoshiwei Technology, MediaTek, IBM, RTX Corporation, pSemi, Winbond electronics, Sony, NVIDIA, Haiguang Information Technology, Shanghai Huali Integrated Circuit Manufacturing, JCET Group, SEMES, Tectus Group, Hanmi, Western Digital, Shibaura Mechatronics, Ningbo Semiconductor International Corporation (NSI), HIDM - Huaian Imaging Device Manufacturer, Bruker, Suzhou Ultiview Technology, KLA, Shanghai Fudan Microelectronics Group, Anhui Xinbiyou Information Technology, Tokyo Electron, Shanghai Yibu Semiconductor, HTSI, GROQ, Dixtech innovation, Qingdao New Core Technology, PsiQuantum, Canon, Infineon, Shanghai Biren Intelligent Technology, Yangtze River Advanced Storage Industry Innovation Center, G-ray Switzerland, and more.

TABLE OF CONTENTS**INTRODUCTION** **5**

- Context and objectives of the report
- Scope of the report
- Reading guide
- Excel database

EXECUTIVE SUMMARY **11****EXCEL DATABASE**

Excel file that includes all patent selected for this study, along with the complete data by assignee from the statistical analyses.

PATENT LANDSCAPE OVERVIEW **20**Main trends and IP players **21**

- Time evolution of patent publications
- Main patent assignees
- Timeline of IP players
- Typology of main IP players
- IP newcomers
- Current legal status of main players' patents
- IP leadership of patent assignees and evolution from 2019
- Geographical coverage of main players' patents

Main IP collaborations **34**

- Co-owned IP
- IP transfers
- Licensing agreements

Patent segmentation **38**

- Segments definition
- Type of claimed invention:
 - Hybrid bonding manufacturing process and interface engineering

- Apparatus/Equipment for hybrid bonding
- Semiconductor structure or device made using hybrid bonding interconnects
- Targeted applications
 - Image sensor (SPADs, CMOS image sensors, light sensing devices, etc.)
 - 2.5D/3D IC (assembly of any type of IC dies, excluding memory-on-memory)
 - 3D-stacked memory (memory-on-memory)
 - Other applications (RF, MEMS, Photonics, LEDs, etc.)
- Time evolution of patent publication by segment
- Main patent assignees by segment
- IP leadership of patent assignees for each segment

KEY PATENTS **48**

- Most important patents in terms of prior-art, IP risks and technology
- Segments to which key patents belong
- Owners of key patents

IP PROFILE OF A SELECTION OF PATENT ASSIGNEES **52**

TSMC, Adeia/Xperi, TongFu, ASE

For each player:

- Patent portfolio overview (IP dynamics, segments, legal status, geographic coverage, etc.)
- Description of key patents
- Description of recent patent applications

PATENT LITIGATION **67****ANNEX** **70**

- Methodology for patent search, selection and analysis
- Methodology to identify key patents
- Terminology

KNOWMADE PRESENTATION **76****AUTHORS****Dr. Pauline Calka**

Pauline works for Knowmade as a patent analyst in the fields of semiconductor manufacturing and advanced packaging. She holds a PhD in Memory from the University of Grenoble Alpes (France), in partnership with the CEA-Leti (France). After an Alexander von Humboldt Postdoc fellowship position at the Technical University of Berlin (Germany) and the Leibniz Institute for High Performance Microelectronics on ReRAM development, Pauline worked five years at ASM International (Belgium) as Senior Process Engineer on thin film development for logic, memory and MEMS, and two years at CEA-Leti as Integration Engineer on imaging CMOS sensors.

Contact: pauline.calka@knowmade.fr

**Dr. Nicolas Baron**

Nicolas is CEO and co-founder of Knowmade. He manages the development and strategic orientations of the company and personally leads the Semiconductor department. He holds a PhD in Physics from the University of Nice Sophia-Antipolis, and a Master of Intellectual Property Strategies and Innovation from the European Institute for Enterprise and Intellectual Property (IEEPI) in Strasbourg, France.

Contact: nicolas.baron@knowmade.fr

ABOUT KNOWMADE

KnowMade is a technology intelligence and IP strategy consulting company specialized in analyzing patents and scientific publications. The company helps innovative companies, investors, and R&D organizations to understand competitive landscape, follow technological evolutions, reduce uncertainties, and identify opportunities and risks in terms of technology and intellectual property.

KnowMade's analysts combine their strong technology expertise and in-depth knowledge of patents with powerful analytics tools and methodologies to turn patent information and scientific literature into actionable insights, providing high added value reports for decision makers working in R&D, innovation strategy, intellectual property, and marketing. Our experts provide prior art search, patent landscape analysis, freedom-to-operate analysis, IP due diligence, and monitoring services.

KnowMade has a solid expertise in Compound Semiconductors, Power Electronics, Batteries, RF Technologies & Wireless Communications, Solid-State Lighting & Display, Photonics, Memories, MEMS & Sensors, Semiconductor Packaging, Medical Devices, Medical Imaging, Microfluidics, Biotechnology, Pharmaceuticals, and Agri-Food.

ORDER FORM

Hybrid Bonding

Patent Landscape Analysis – August 2024

Ref.:KM24003

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

Order online: Click [here](#)

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, Le Drakkar
06560 Valbonne Sophia Antipolis
FRANCE

Money Transfer

To pay your invoice using a bank money wire transfer, please contact your bank to complete the process. Here is the information you will need to submit the payment:

Payee: KnowMade S.A.R.L.
Bank: Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var
IBAN: FR76 1460 7003 6360 6214 5695 139
SWIFT: CCBPFRPPMAR

Paypal

To pay your invoice via PayPal, you must first register at www.paypal.com. You can then send money to KnowMade S.A.R.L. by entering our email 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, Le Drakkar, 06560 Valbonne Sophia Antipolis, FRANCE

PRODUCT ORDER

4,990 EUR – Multi user 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.

**The report can be shared with the employees of the company purchasing the report. Subsidiaries and joint-ventures are excluded. Please be aware that the report is watermarked on each page, with the name of the recipient and the organization (the name mentioned in the PO). This watermark also reaffirms that 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. Multi user license: the report can be used by unlimited users within the company. Subsidiaries and Joint Ventures 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-equivocal 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 Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var

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

4.3 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.

4.4 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.