

# Miniaturized Gas Sensors

## Patent Landscape Analysis – December 2018

*Miniaturized gas sensors will be increasingly used in HVAC, air comfort for transportation and consumer applications. But do the key gas sensor market players have the best IP positions?*

### REPORT OUTLINE

- Miniaturized gas sensors
- Patent landscape analysis
- December 2018
- Ref.: KM18008
- PDF >140 slides
- Excel file >3,500 patents
- €6,490 for a multi-user license



### REPORT'S KEY FEATURES:

- **IP trends**, including time-evolution of published patents, and countries of patent filings
- Patents' **current legal status**
- Ranking of **main patent assignees**
- **Key players' IP position** and **relative strength** of their patent portfolios
- IP analysis of **sensing technologies**: electrical, thermal, optical, electro-chemical, electro-mechanical, acoustic, chromatography, etc.
- **Key players, new entrants** and **key patents** for each sensing technology
- Key patents near **expiration** date
- **BOSCH** and **AMS** IP profiles and IP comparison
- **Excel database** containing all patents analyzed in the report, including technology segmentation

### LINKED REPORTS

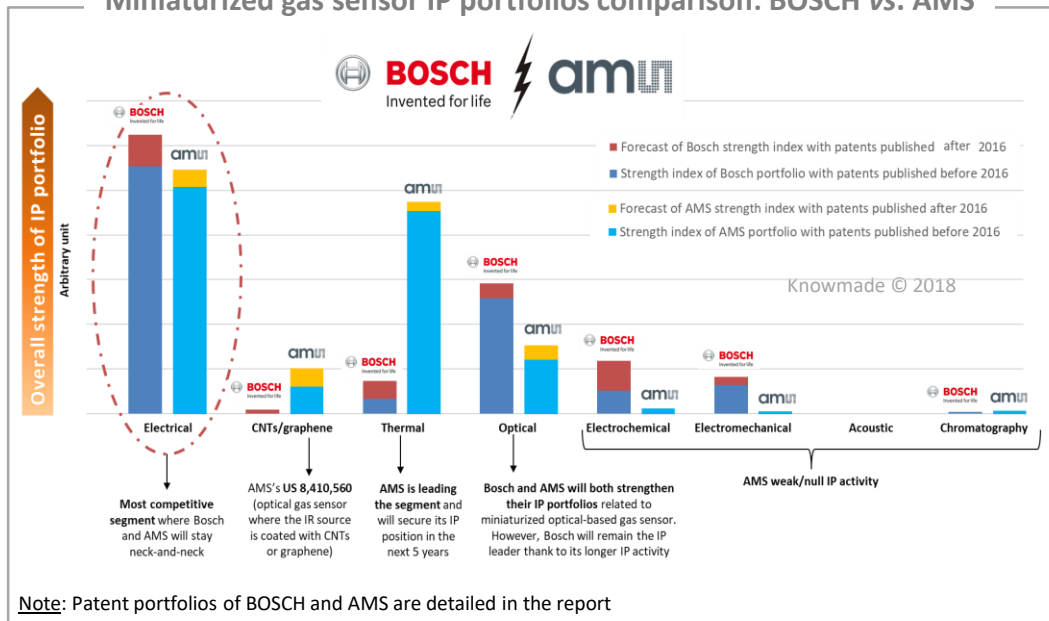
- [Miniaturized Gas Sensor Comparison: Bosch, ams and Sensirion](#), Oct. 2018, System Plus Consulting
- [Gas and Particle Sensors](#), Nov. 2018, Yole Développement.

### BOSCH and AMS dominate miniaturized gas sensor related patents

The gas sensor market is growing, driven by **Heating, Ventilation and Air Conditioning (HVAC)** and **air comfort for transportation** which are poised to experienced the **highest Compound Annual Growth Rates (CAGRs)** from 2017-2023 of 15% and 12.5% respectively, according to Yole Développement's report [Gas and Particle Sensors 2018](#). The **miniaturization of gas sensors** has allowed their introduction to consumer applications and their manufacture in large volumes. We believe **miniaturized gas sensors** will be increasingly used to resolve **form-factor/cost issues** in consumer, HVAC and air comfort for transportation applications.

At the beginning of this new era for gas sensors, understanding the **Intellectual Property (IP) position** and **strategy** of historical gas sensor players as well as identifying the **key IP players** and the **newcomers** is crucial. In this report, Knowmade has thoroughly investigated the **patent landscape related to miniaturized gas sensors**, covering gas sensing technologies using micro-fabrication techniques to reduce form-factor, cost and power consumption. Our patent landscape analysis shows **significant changes** in the competitive IP landscape since our previous analysis in 2016.

### Miniaturized gas sensor IP portfolios comparison: BOSCH vs. AMS



We have seen a **big increase in patenting activity** related to miniaturized gas sensors in 2017-2018, mainly due to new inventions from **Bosch, AMS, NGK, Sensirion** and from **new entrants** such as **MicroJet Technology, Spirosure, Carrier Corporation, LG** and **Apple**. The patent filings currently pending reflect a particular interest of the competitors in **European and Chinese markets**. Historical IP players **Siemens, Honeywell** and **General Electric** have the strongest patent portfolios, especially **Siemens**, which shows the most important contribution to the prior art in the field of miniaturized gas sensors.

**Bosch** is indisputably this field's current **IP leader**, and in the last two years it has strengthened its IP position in both miniaturized **electrical** and **optical** gas sensing technologies. **AMS** is the IP player that saw the **biggest change in its IP position** in miniaturized gas sensors in recent years. **AMS'** IP portfolio now benefits from **key patents** from recent acquisitions of CCMOS Sensors, Applied Sensor and NXP's CMOS sensor business, which today offer it the capability to limit the IP activity of other players, especially on **electrical** and **thermal** miniaturized gas sensors. **TDK-Micronas** and the **CEA** French R&D Lab own the highest number of enforceable patents relating to miniaturized gas sensors, but both decreased their patenting activity in the last two years, which could affect their IP position in the future.

### Analysing patents of each sensing technology

The patents have been **categorized** according to the claimed **sensing technology**, including electrical, thermal, optical, electro-chemical, electro-mechanical, acoustic and chromatography. In this report we analyze patents of each sensing technology and discuss the **relative strength of the patent assignees**, highlight the **key patents** and identify the **IP newcomers**.

From a patent point of view, the **electrical** and **thermal** technologies remain the two **most competitive miniaturized gas sensor segments**. **TDK Micronas** and **Siemens** are the best **established IP players** in **miniaturized electrical gas sensor** segment, but they suffer from **low patenting activity levels** that limit their ability to strengthen and develop their IP position in coming years. **Bosch** and **AMS** will stay neck-and-neck in the **electrical IP** segment while **AMS** is leading the **thermal** segment and will probably secure its IP position in the next few years. **Bosch** and **AMS** currently compete in the **thermal gas sensors IP** segment, while **TDK-Micronas** and **VTT** are just entering the IP landscape.

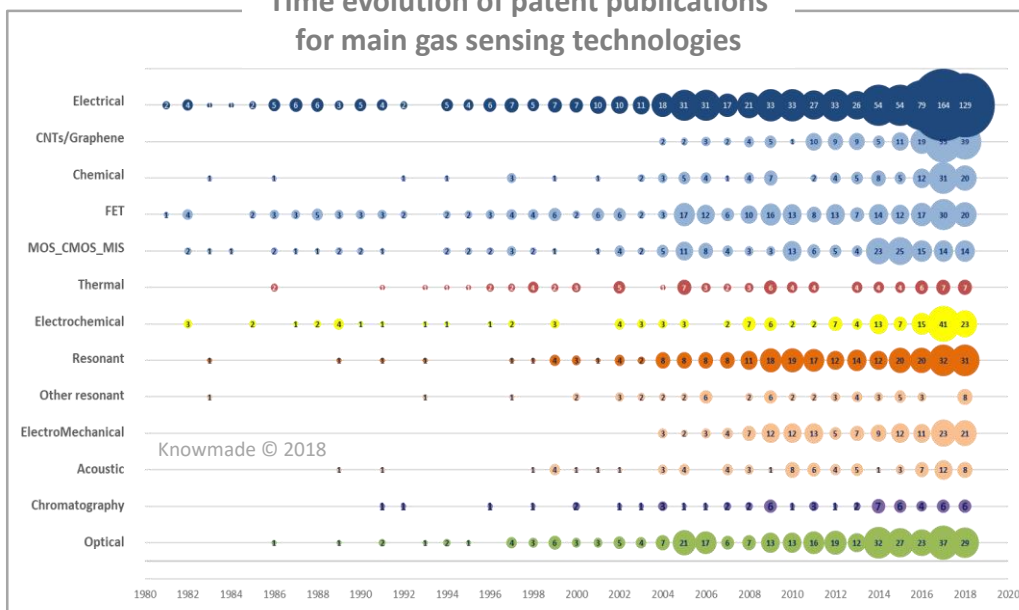
Key IP players and IP newcomers by sensing technology

	ELECTRICAL	OPTICAL	THERMAL	ELECTRO-CHEMICAL	ELECTRO-MECHANICAL	ACOUSTIC	CHROMATOGRAPHY
Key IP players still active	BOSCH amut	BOSCH amut Infineon	amut BOSCH	BOSCH NGK SPEC SENSORS	cea BOSCH	Infineon VTT Alpha MOS	cea Alpha MOS
Key IP players with decreasing or no longer IP activity	SIEMENS TDK TDK-Micronas	Honeywell GE	NXP Ford	SRI	Agency for Science, Technology and Research VTT	SIEMENS ProterixBio Honeywell TRICORNTech cea	TRICORNTech
IP newcomers (non exhaustive)	spiroSure NISSHA Goertek Invensense	intel SENSIRION amos	TDK TDK-Micronas VTT	spiroSure FIGARO ANALOG DEVICES Withings	SENSIRION MicroJet	KAIST ttp Matrix Sensors BOYDSense	iSenLab MicroJet trueDyne

Note: All segments are detailed in the report

The IP landscape relating to **miniaturized optical gas sensors** is also competitive but less settled than the electric one. **Honeywell** is the most **established IP player** with the highest number of enforceable patents and several seminal patents. **Bosch** is **leading patenting activity** in optical sensing technology, but **Infineon** and **AMS** are its two main IP competitors. The **electro-chemical gas sensor**-related IP landscape is small but has seen a **strong boost** in patenting activity in 2017 thanks to **Bosch's** new patent filings on solid electrolyte technology. Beside other IP players involved in **electro-chemical sensing technology** like **NGK** and **Spec Sensors**, we noticed the entrance of **SpiroSure**, which has co-filed patents with **NGK**, **Analog Devices**, **Figaro Engineering** and **Withings**, which was formerly Nokia Health.

Time evolution of patent publications for main gas sensing technologies



The patenting activity related to **electro-mechanical gas sensors** has shown a progressive increase since 2012. The **electro-mechanical IP segment** is dominated by academic players like the **CEA** in France and by recent patenting activity of **Bosch**, and we observed the entrance of **IP newcomers** like **MicroJet Technology**, **Sensirion** and **Nissha**. **Infineon** is currently the most active IP player in **miniaturized acoustic gas sensors**. Other key patent owners involved in **acoustic sensing technology** are **Siemens**, **Honeywell**, **CEA**, **Tricorntech**, **VTT** and **ProterixBio**. The IP landscape relating to **chromatography-based miniaturized gas sensors** comprises few patents owned by R&D labs like **CEA** and small companies like **Alpha MOS**, **MicroJet Technology**, **TrueDyne Sensors**, **iSenLab**.

The report also includes an **Excel database** with the **>3,500 patents** analyzed in this study. This useful patent database allows for **multi-criteria searches** and includes patent publication numbers, hyperlinks to the original documents, priority date, title, abstract, patent assignees, each patent's current legal status, and **sensing technologies**.

**COMPANIES MENTIONED IN THIS REPORT (NON-EXHAUSTIVE LIST)**

Bosch, AMS, Siemens, Honeywell, TDK-Micronas, NGK, CEA, Infineon, VTT, General Electric, Figaro Engineering, LG, Spec Sensors, Spirosure, Sensirion, MicroJet Technology, iSenLab, Truedyne, InvenSense, TricornTech, Alpha MOS, ProterixBio, NXP, Ford, Nissha, Goertek, Sumitomo, Withings, Analog Devices, A\*STAR, CalTech, Cyrano Sciences, PARC, Toshiba, Fujitsu, Intel, amos, SRI International, KAIST, NUAU, etc.

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**ABOUT KNOWMADE**

Specialized in the analysis of patents and scientific information, **Knowmade** provides technology intelligence and IP strategy consulting services. The company supports the business development of R&D organizations, industrial companies, and investors by offering them a deep understanding of their IP environment and technology trends.

**Knowmade** operates in the following industrial sectors: compound semiconductors, power electronics, RF devices and technologies, solid-state lighting and display, photonics, memory, MEMS and sensors, semiconductor manufacturing and advanced packaging, battery and energy management, biotechnology, pharmaceuticals, medical devices, medical imaging, and agri-food.

**Knowmade's** experts provide prior art search, patent landscape analysis, scientific literature analysis, patent valuation, IP due diligence, and freedom-to-operate analysis. The company also delivers litigation/licensing support, technology scouting, and IP/technology observation. **Knowmade's** analysts combine their technical and patent expertise with powerful analytics tools and proprietary methodologies, delivering invaluable patent analyses and scientific reviews.

# ORDER FORM

## Miniaturized Gas Sensors

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Ref.: KM18008

### 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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#### Check

To pay your invoice using a check, please mail your check to the following address:

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06902 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:

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

#### Paypal

To pay your invoice via PayPal, you must first register at [www.paypal.com](http://www.paypal.com). You can then send money to KnowMade S.A.R.L. by entering our email address ([contact@knowmade.fr](mailto:contact@knowmade.fr)) as the recipient, and entering the invoice amount.

#### RETURN ORDER BY:

**Email:** [contact@knowmade.fr](mailto:contact@knowmade.fr)

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#### PRODUCT ORDER

- €6,490 – Corporate license  
 €5,990 – Single-user license\*

For the price in dollars, please use the current day's exchange rate. French customers, please add 20% for VAT.

Upon payment reception, all reports are delivered electronically in pdf format

*\*Single-user license means only one person at the company can use the report. Please be aware that the report is watermarked on each page, with the name of the recipient and the organization (the name mentioned on 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

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“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.

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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-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 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.

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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 payment, 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

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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.

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.

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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.

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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:

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- 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);
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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.

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

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## 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.