

MEMS PRESSURE SENSORS - TECHNOLOGY AND MARKET TRENDS 2021

Market & Technology Report - April 2021

Healthy growth is expected for the pressure MEMS market in the next five years, but uncertainty comes after 2026, due to the transition to EVs, eventually exerting pressure to sensor manufacturers.

WHAT'S NEW

- Updated market forecasts in \$ and units for the period 2016–2026
- Up-to-date analysis of more than 29 applications in five different markets, including consumer, automotive, industrial, medical, defense and aerospace
- Latest market trends by end-market and application
- Focus on EVs and impact on pressure MEMS
- 2019 and 2020 estimates for sensor manufacturers' market shares
- Ecosystem and supply chain updated description
- Technology trends

REPORT OBJECTIVES

This report is an update of Yole's "MEMS Pressure Sensors" report. This edition is an updated version with some minor revamping of historical volumes/ASP/market sizes. The analysis and market consolidation/forecasts were done during March 2021 using Yole's database, with the effect and hypotheses regarding covid-19 recovery and other market dynamics, up to that date. Therefore, the data that you will find in this report is the best available data, to date. This report summarizes the status of the MEMS pressure sensor industry in a thorough manner, taking into account the trends for each application and market separately. Focus of this version is green mobility and electrification, that has significant implications for the future of MEMS pressure sensors.

THE AUTOMOTIVE MARKET IS STILL DRIVING REVENUES FOR PRESSURE MEMS – BUT FOR HOW LONG?

Pressure sensors are widely used throughout the industry across numerous applications. In the last couple of decades, automotive has been one of the main sectors to drive demand for these devices. The development of new systems in conventional internal combustion engine vehicles, as well as hybrid electric vehicles, is demanding complex control systems.

Many different sensing technologies have been used so far for measuring pressure in automotive, industrial, defense & aerospace and other harsh environments. Examples include strain gauges on metal substrates, plus capacitive and piezo-resistive sensors using ceramic materials that are used to sense pressures of several tens or hundreds of bars. But for pressure levels below the 5-10 bar mark their sensing elements become relatively big and expensive. This is where MEMS pressure sensors have strongly penetrated.

The global pressure MEMS market amounted to \$1,685M in 2019, expected to slightly drop to \$1,645M in 2020 due to COVID-19 ebbs and flows. By 2026, the whole market is expected to grow to \$2,214M, at a 4% Compound Annual Growth Rate (CAGR₂₀₁₉₋₂₀₂₆).

During recent years, miniaturization, low power, and cost effectiveness have allowed the consumer market to grow significantly, mainly due to the use of pressure MEMS barometers and

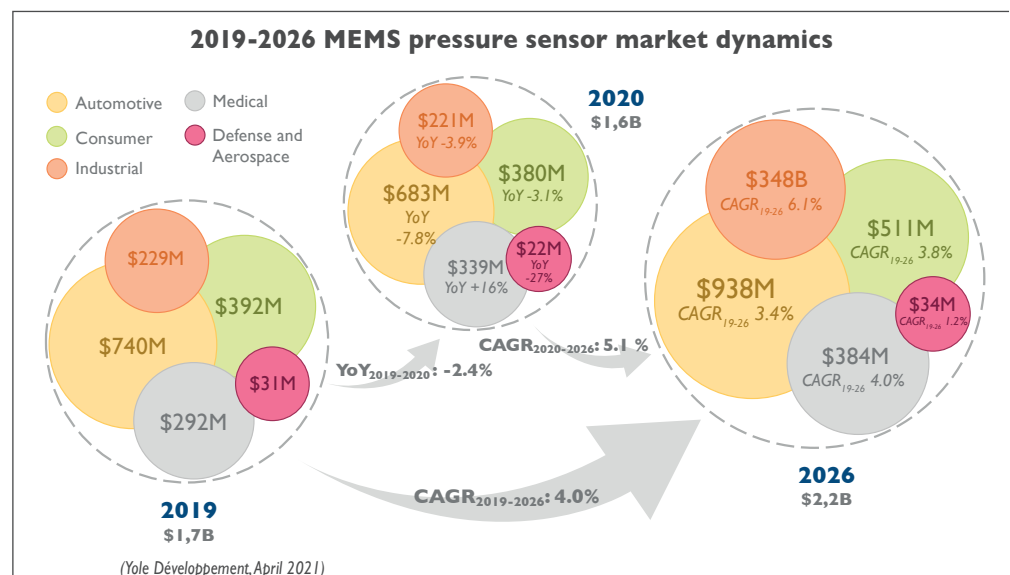
altimeters in smartphones, drones, e-cigarettes and consumer white goods. This technology will continue gaining traction by other use-cases, such as 911 e-calls now that all US smartphones must integrate a pressure sensor, for exact altitude positioning, higher attachment rate in smartphones, wearables applications and e-cigarettes.

In medical applications, miniaturization of pressure MEMS has allowed their use in invasive applications like blood pressure monitoring. Other niche markets like catheters, inflating device monitoring for cardiovascular applications that are invasive and require high accuracy, low-cost sensors, are fully using the advantages of MEMS technologies and could foster broader use in the medical market.

The industrial market is also interesting to follow. Because we are at the verge of Industry 4.0 and factory automation, process control and smart meters could present good growth opportunities.

Defense & aerospace pressure MEMS comprise less than 5% of the total pressure MEMS market, growing only slowly and gradually replacing older technologies.

Finally, in the automotive market pressure MEMS continue to grow thanks to the evolution towards greener driving and increased autonomy



levels that demand enhanced safety. Tire pressure monitoring systems (TPMS) and China 6 regulations will cause the Diesel and Gasoline Particulate Filter (DPF/GPF), Evaporative Emissions Control Systems (EVAP), Exhaust Gas Recirculation (EGR) and TPMS applications to grow in the future. However, one risk is imminent. The recent acceleration of battery Electric Vehicles (EV) could mean the slow-down of pressure sensors in the traditional internal

combustion engine (ICE) powertrain. But new applications could emerge, such as thermal runaway monitoring in battery cells, promising significant growth.

For the moment and in the next 5-10 years to come at least, powertrain pressure MEMS will keep growing modestly. However, the big question arises is what happens beyond the next decade as the classic ICE powertrain dies.

THE POSITIONS OF THE MAIN STAKEHOLDERS AND THE START OF CONSOLIDATION

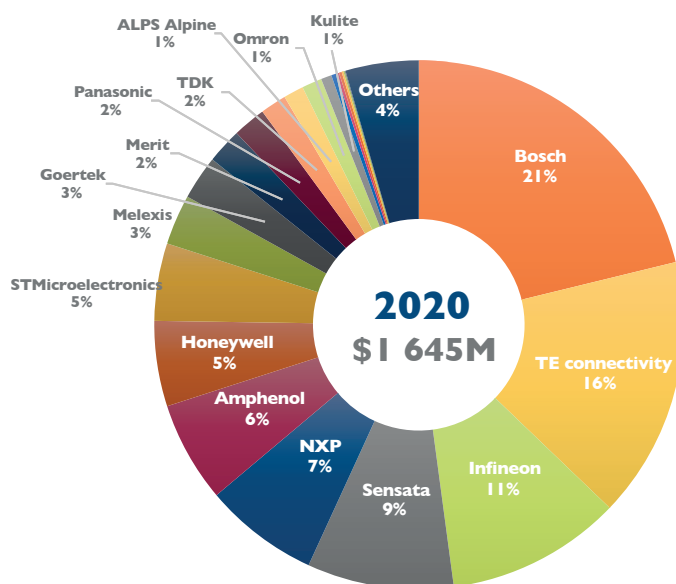
Pressure MEMS, being a historically stable market, has not experienced any dramatic changes in its player landscape, besides some recent mergers and acquisitions. In the past two years big players like Amphenol and TE Connectivity were hungry

to strengthen their pressure MEMS portfolios and synergies.

Today's top three pressure MEMS players – Bosch, TE Connectivity and Infineon – are already well established and technologically advanced, operating with large economies of scale. They occupy almost half of the \$1,645M total market. Bosch and Infineon were consistently leaders in the past. Bosch has a strong presence in the automotive and consumer market, and Infineon is mainly in the automotive market. TE Connectivity has climbed up the rankings due to the acquisitions of SMI and First Sensor, acquiring significant capabilities for pressure MEMS in medical and industrial markets. Now TE Connectivity has a diversified portfolio.

Furthermore, there hasn't been any significant funding of new pressure MEMS companies in the last years. This is reasonable, since pressure is a traditional MEMS device that has existed for over 30 years, and MEMS has high entry barriers in terms of capital and technology for newcomers. One wonders if the consolidation of such an established market will continue and smaller players will keep getting acquired by big conglomerates.

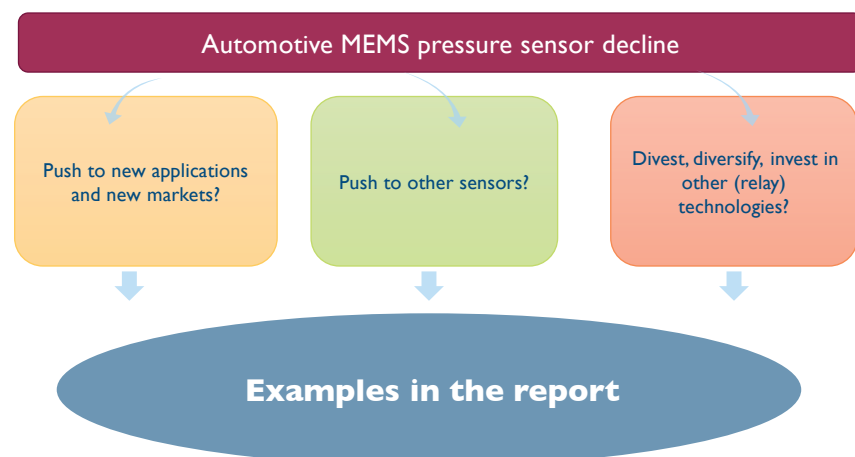
2020 MEMS pressure sensor players revenues (\$M)



(Yole Développement, April 2021)

PLAYERS' POSSIBLE DIFFERENTIATION STRATEGIES IN PREPARATION OF THE PRESSURE-LESS AUTOMOTIVE WORLD OF THE FUTURE

MEMS pressure sensor companies and future automotive strategies



(Yole Développement, April 2021)

The pressure MEMS industry might grow only modestly in the next five years. However, it is at the brink of an imminent decline due to the disappearance of automotive pressure MEMS in ICE powertrains. For the moment, the proliferation of hybrid vehicles that have both ICE and electric powertrains, is not a threat but a sweet spot. Pressure MEMS will still be needed for hybrid EVs, due to the presence of the classic ICE. But beyond 10 years the pure EV will start winning over hybrid and ICE vehicles, which could become a problem for pressure sensor manufacturers.

There is a risk of more than 100 million units of powertrain pressure MEMS disappearing annually in 10-15 years' time. Although this wall is further ahead, manufacturers and main stakeholders active in this domain have a few years ahead of them in order to assess the situation and react. Therefore, decisions must be taken soon. Will companies

target new markets away from automotive? Or will they look for new applications and novel use-cases? Will they redirect strategy towards other types of sensors? Or will they make acquisitions, leading to market and power consolidation?

COMPANIES CITED IN THE REPORT (non exhaustive list)

Alps Alpine, Altria, Amphenol, APM, Autochips, Baolong, BAT, BMW, Bosch, CF Sensor, Continental, Danfoss, Delphi, Denso, SMI (Elmos), First Sensor, Fuji Electric, GE Druck, Goertek, Hamilton Medical, Hiway, Honeywell, Infineon, Invensense, JTI, Juul, Kistler, Keller, Kulite, Medtronic, Meggit, Melexis, Memscap, MEMSensing Microsystems, Merit Sensor, Merit Medical, MT Microsystems, Murata, Nano-MEMS, Navinfo, Nextnav, NXP, OMB Warehouse, Omron, Onkar, Panasonic, Philip Morris International, Philips Healthcare, QST, Rohm, Schraeder, Senasic, Sensata, Sensirion, ShuangQiao Sensors, STMicroelectronics, Syrik, TDK, TE Connectivity, Teledyne, Tesla, Tire Safeguard, Thales, Toyota, TPMS Warehouse, Visture, Volkswagen, X-Fab, and more.

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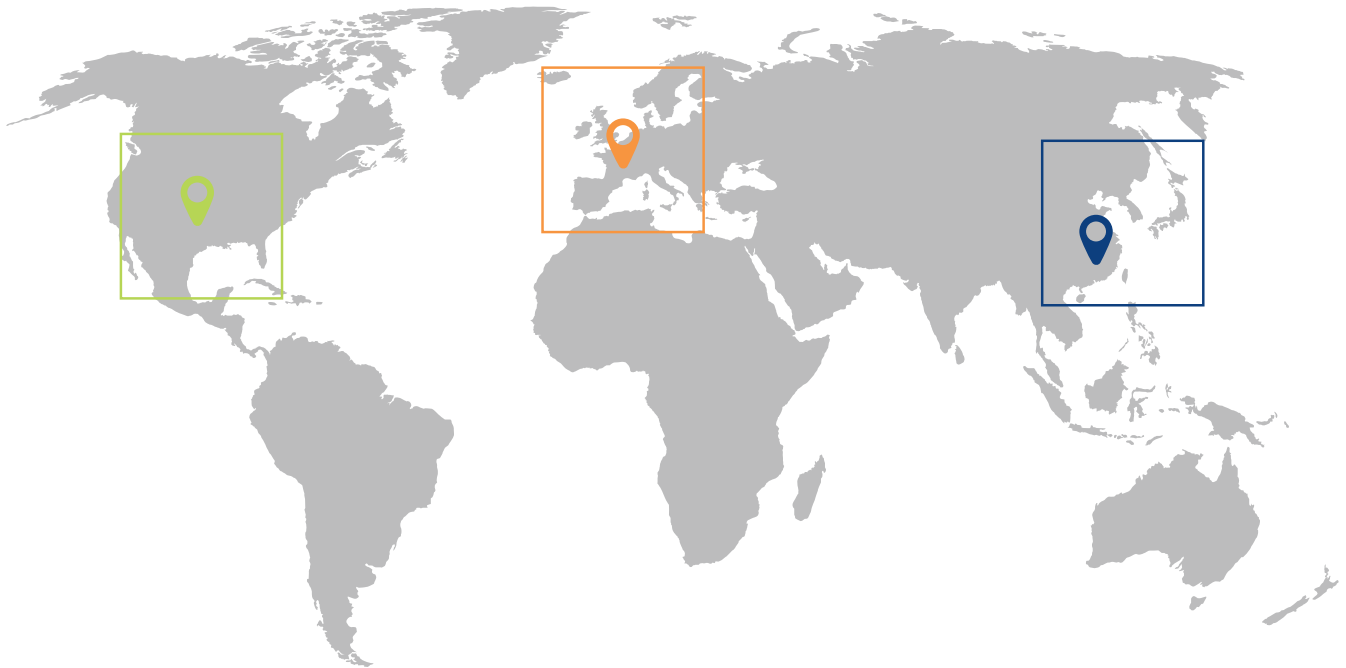
RELATED REPORTS, MONITORS & TRACKS



- Status of the MEMS Industry 2020
- MEMS Pressure Sensor Comparison 2018
- Wearables in Consumer and Medical Applications 2020
- Power Electronics for E-Mobility 2021
- Infineon DPS310 Capacitive Pressure Sensor

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Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 120 collaborators worldwide covering MEMS and Image Sensors, Compound Semiconductors, RF Electronics, Solid-state Lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Power Electronics, Batteries & Energy Management and Memory.

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Bank code: 30056
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Account n°: 0170 200 1565 87
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8.1 All the provisions of these General Terms and Conditions of Sale are for the benefit of the Seller, but also for that of its licensors, resellers and agents. Each of them is entitled to assert and enforce these provisions against the Buyer.

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

8.2 The Seller may, from time to time, update these General Terms and Conditions of Sale, and the Buyer, shall be deemed to have accepted the latest version of such General Terms and Conditions of Sale, once they have been duly communicated to the Buyer by the Seller.

9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these General Terms and Conditions of Sale or to any Licenses or Products purchased in application thereof shall be submitted to the French Commercial Court of Lyon, which shall have exclusive jurisdiction upon such issues.

9.2 French law (without reference to any applicable conflict of law provisions) shall apply to these General Terms and Conditions of sale and any agreement between the Buyer and the Seller made pursuant thereto.