

STATUS OF THE MEMS INDUSTRY 2020

Market & Technology Report - July 2020

Edge processing and subsequently computing will boost the MEMS market. Will manufacturers have access to the new MEMS added value?

WHAT'S NEW

- Effect of COVID-19 in MEMS markets
- Updated market forecasts in \$ and units for the period 2019–2025
- Up-to-date analysis of more than 15 different devices, including inertial, microphones and pressure in six different markets, including consumer, automotive, industrial, medical, telecom, defense and aerospace
- 2019 estimates for sensor manufacturers' market share and evolution
- Latest market trends by end-market and device type
- Technology trends at the manufacturing level, device level and software/processing level

REPORT OBJECTIVES

This report is an update of Yole Développement (Yole) best-selling "Status of the MEMS Industry" report, which was first released in 2004. This latest edition is an updated version of 2019 volumes/ASP/market sizes. The analysis and market consolidation/ forecasts were done during May 2020 using Yole's database, with the effect and hypotheses regarding COVID-19, dating end of April 2020. The report was finalized end of June 2020. Therefore, the data that you will find in this report is the best available data to date. This report summarizes the status of the 2020 MEMS industry in a thorough manner, taking into account the trends for each application separately as well as the effect of COVID-19.

HOW COVID-19 HAS CHANGED THE MEMS MARKET'S DYNAMICS

2020 is the year that COVID-19 has changed our view about the world, from finance to ecology to us, humans. Naturally, it is expected that there will be an effect on MEMS markets. Yole Développement (Yole) has accounted for positive and negative scenarios regarding the main markets, applications and devices concerned.

Not all MEMS markets will be affected in the same way by the pandemic. This is a chance for MEMS to be used in very different applications. While home working will favor the market for data centers and accelerate the deployment of 5G, the lockdown has slammed the brake in markets such as automotive and, in a lesser extent, consumer devices due to a dramatic drop in demand.

MEMS for consumer devices will be mainly supported by radio-frequency (RF) MEMS. It will continue to grow in 2020 and beyond due to the expanding 5G and sub 6 GHz band rollout that precipitates the need for Bulk Acoustic Wave (BAW) filters. Including RF MEMS consumer market contracts only by 2.6%, but without RF MEMS it is poised to slump by 16% in 2020. A recovery to pre-COVID levels is expected in 2021, and growth will resume.

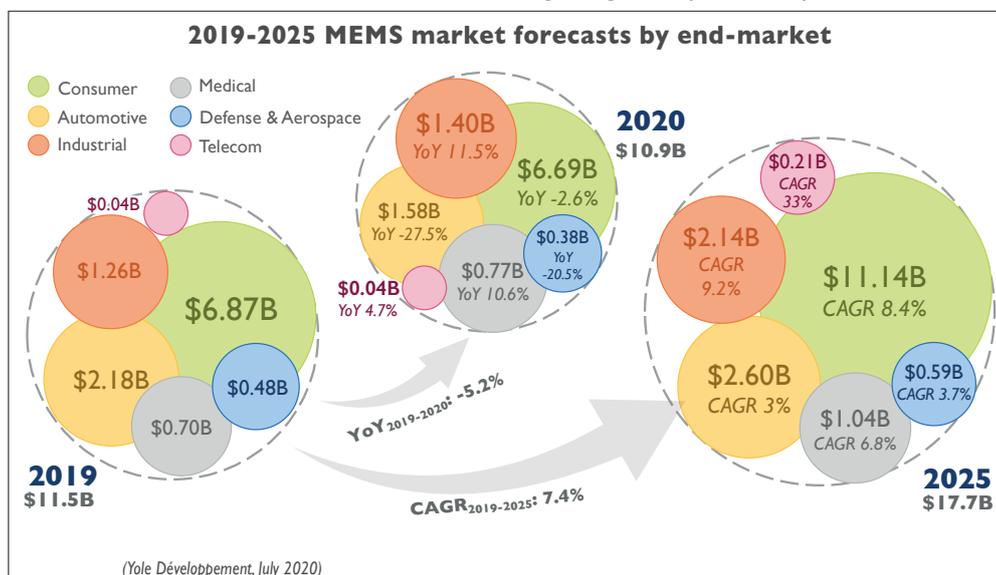
In automotive, the negative effects of COVID-19 will be prominent with a -27.5% YoY decline in 2020 and most devices related to automotive will suffer because of the drop in the market, including sensing, lighting and power. Pressure and inertial MEMS will continue to lead this

market, since they are indispensable in safety systems such as tire pressure monitoring systems (TPMS), airbags, electronic stability control (ESC) and roll-over detection. While being a small market currently, MEMS oscillators present a good growth opportunity in the future with a 45% Compound Annual Growth Rate from 2019 to 2025 (CAGR₂₀₁₉₋₂₀₂₅) due to 5G automotive vehicle-to-everything (V2X) connectivity.

Industrial MEMS will profit from the COVID-19 pandemic, as thermal imaging and sensing systems, both thermopile and microbolometer based, surge due to the need for contactless body temperature measurement.

The medical MEMS market is mostly dominated by pressure and microfluidics and will continue this way. Areas directly linked to COVID-19, including ventilators, respiratory diagnostics, research tools to study the virus and patient monitoring are positively impacted while other healthcare areas experience moderate to no impact. Furthermore, microfluidics diagnostic tests are of paramount importance for the diagnosis of COVID-19. In the transformation of healthcare organization, the COVID-19 pandemic will probably accelerate technology requirements towards a patient-centric approach. There will be more telehealth, more wearable, hearable and connected medical devices and more prevention and continuous monitoring.

The telecommunications segment presents the highest growth potential up to 2025, as MEMS



oscillators grow rapidly since more timing solutions will be needed for 5G. And telecom operators are determined to continue to accelerate 5G deployment in 2020, thus growth will be here. Nevertheless, it's a small market and will continue to be so.

The defense and aerospace market will slump in 2020, due to civil aviation paralysis, although defense will not feel any significant effect. Traditional MEMS sensors including pressure and inertial could be affected negatively, since new aircraft orders are being hindered. However, in the longer

term, thermal imagers based on microbolometers present a good opportunity in defense applications as they keep replacing legacy thermal cameras using older cryo-cooler based technologies. In a general way, defense is not so much impacted by COVID-19 as governmental programs will continue.

In general, between 2019–2025 global MEMS revenue should grow from \$11.5B to \$17.7B at a 7.4% CAGR. The consumer market is and will continue to be the biggest market for MEMS with around 60% of the total, with automotive following in second at less than 20% of the total.

A CONSTANT MEMS BATTLE ROYALE

On the MEMS player side, the picture in 2019 was not the same as 10 years ago, when Texas Instruments (TI) and HP were leading, with Bosch and STMicroelectronics following, all at comparable revenue levels. Now, Broadcom and

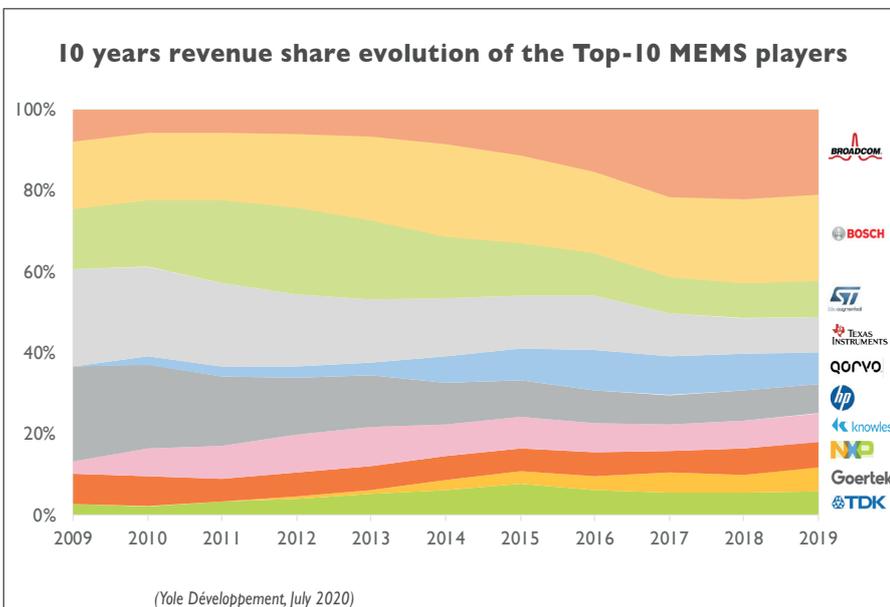
Bosch lead with almost \$1.4B revenue each and the rest of the key MEMS stakeholders compete in the \$400M-\$600M league.

Broadcom has gained a significant place during the past 10 years and has stepped up its pace, along with Qorvo, making RF MEMS the champions. However, Bosch is still going strong against Broadcom, showing that MEMS sensors are striking back and still have a lot to offer.

STMicroelectronics, TI and HP dominate a smaller part of the market than 10 years ago, while Knowles and NXP remain pretty much stable. Goertek is continuously accelerating, while TDK is maneuvering forward.

Microphone players profited from the voice interface adoption trend, while players active in MEMS for automotive and smartphones suffered slightly in 2019 due to weak end-system demand.

It should be also highlighted that 12" MEMS wafers have entered production for the first time, used by Butterfly Network for a capacitive micromachined ultrasonic transducer (cMUT) on CMOS. This is a trend Yole analyzed years ago and it came true that 12" makes sense for large MEMS dies.



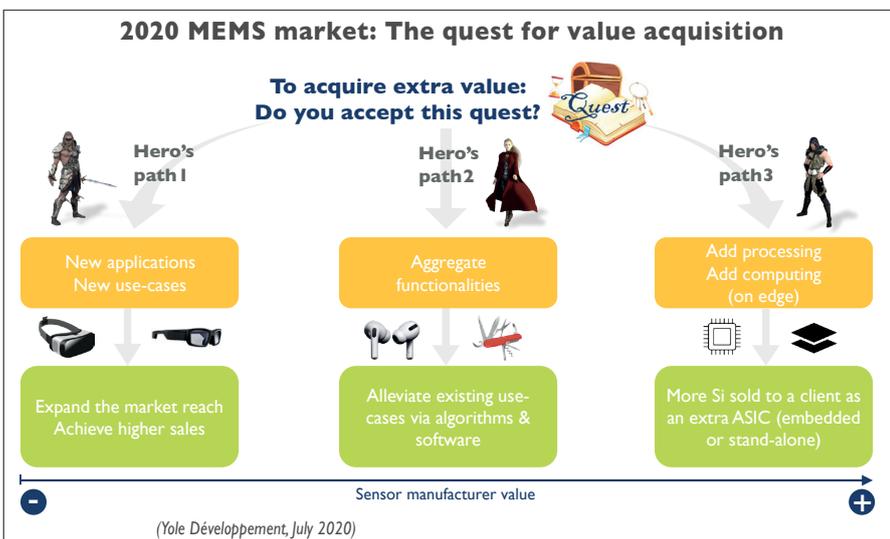
KEY TRENDS CHANGING THE MEMS MARKET AND THE PLAYERS' QUEST FOR ACQUIRING VALUE

Regarding MEMS trends, at the application level and in the medium term, there will be a move to

more wearable ultra-sensitive devices packing a lot of sensors but also a move to more consumer healthcare. Everything related to voice interfaces and voice/virtual-personal assistants (VPAs) will continue to grow strongly, increasing demand for MEMS mics with better quality and high-fidelity voice capture. MEMS devices are shifting to higher accuracy, ultra-low power, embedded intelligence and possibly some bio-compatibility for medical applications.

From their side, MEMS players are trying to escape the commoditization cycle and acquire more value from sensors. This can be achieved in three ways:

- by finding new applications and use-cases of sensors - one example could be AR/VR.
- by aggregating functionalities and ameliorating the existing use-cases via algorithms and software.
- by adding processing and computing 'at the edge'. It increases the value both because of



more silicon area as an extra application specific integrated circuit/microcontroller unit (ASIC/MCU) is added, but also by adding more functionality – this could reverse the price decreasing curve of MEMS that Yole Analysts' have seen for years.

Each player has its own strategy. Knowles, for example, managed to increase its value from the Google Pixel 3 to the Google Pixel 4 smartphone by adding an extra audio processor for Digital Signal Processing (DSP). The acquisition of Audience some years back was critical for reaching this step. While selling MEMS microphones as usual, by adding the

processing function, Knowles increased the value of the silicon sold to Google.

On the other hand, other players are boosting the use-cases in the applications of their clients with extra functionality achieved with better algorithms and software. Bosch is collaborating with Qualcomm, while STMicroelectronics has added a machine learning core in its inertial sensors.

Finally, AI on the edge seems very alluring for even more extra value acquisition, by climbing the value chain even higher. Startups are already working on it, such as Imerai, Aspinity, Syntiant and Cartesiam, and for sure, this will be the next step for MEMS.

COMPANIES CITED IN THE REPORT (non exhaustive list)

AAC, AKM, Alps Electric, Amphenol, ams, Analog Devices, Apple, Arioso, Asia Pacific Microsystems, Aspinity, Audiopixels, Boehringer Ingelheim Microparts, Bosch, Broadcom, Butterfly Network, Canon, Cartesiam, Colibrys, Collins Aerospace (Ex Utc), Cirrus Logic, Csem, Denso, DRS, Epcos, Epson, Esiee, First Sensor Technology, Flir Systems, Formfactor, Fraunhofer Ipms, Fujifilm Dimatix, Gettop, Goertek, Google, Hanking Electronics, Hewlett Packard, Honeywell, imec, Imerai, IMT, Infineon Technologies, Knowles Electronics, Lynred, Maxim, Melexis, MEMSCAP, MEMSensing, MEMSIC, Micralyne, Murata, Nxp, Omron, ON Semiconductor, Panasonic, Qorvo, Qualcomm, Raytheon, Rf360, Rohm, Samsung, Sensata, Sensirion, Si Time, Silex Microsystems, Silicon Sensing Systems, SINTEF, SMI, Sony, STMicroelectronics, Syntiant, Taiyo Yuden, TDK, TE Connectivity, Teledyne Dalsa, Texas Instruments, Tower Jazz, Vis (Vanguard International Semiconductor – Ex Globalfoundries), VTT, TSMC, UMC, Usound, X-Fab, xMEMS and many more.

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RELATED REPORTS, MONITORS & TRACKS



- Thermal Imagers and Detectors 2020 – COVID-19 Outbreak Impact – Preliminary Report
- BioMEMS Market and Technology 2020
- Point-of-Need 2020 – Including PCR-Based Testing
- Consumer MEMS Microphones Comparison 2020 by System Plus Consulting
- Teardown Tracks by System Plus Consulting

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ABOUT YOLE DEVELOPPEMENT

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.

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and Blumorpho, supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

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- Market data & research, marketing analysis
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 - 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.
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Bank code: 30056
Branch code: 00170
Account n°: 0170 200 1565 87
BIC or SWIFT code: CCFRFRPP
IBAN: FR76 3005 6001 7001 7020 0156 587

To secure the payments due to the Seller, the Seller reserves the right to request down payments from the Buyer. In such case, the need for a down payment will be mentioned on the corresponding order.

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8. MISCELLANEOUS

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.