MEMS are characterized by a wide range of different designs and manufacturing technologies, with no standardized processes. MEMS' application scope is broad and also very fragmented and diversified - thus, MEMS packaging must always cope with different end-application requirements (i.e. protection in different media, hermeticity, interconnection type, and thermal management). This creates many challenges for the packaging industry, which faces different package configurations (open, closed) for many different application constraints: from the need for low-cost packaging in consumer applications, to the ability to withstand high temperature and harsh environments for automotive and aeronautics packaging.

We estimate that the MEMS packaging market will grow from a market value of $2.56B in 2016 to $6.46B in 2022 - a 16.7% CAGR over this period. Driven by the complexity associated with the move to 5G and therefore the increasing demand for RF filters in 4G/5G, the largest MEMS growth will be for RF MEMS (BAW filters). Optical MEMS (including micro mirrors and micro bolometers) are second with a 28.5% CAGR, driven by consumer, automotive, and security applications. Acoustic and ultrasonic (including microphones) are third. Demand for audio processing is particularly strong, with high unit growth for MEMS microphones targeted at increasingly sophisticated applications that use the microphone to continuously sense what is happening around it, i.e. for smartphones or inside/outside the car, factory, or home.

The MEMS packaging market’s value is growing faster than the MEMS device market’s value: respectively, a 16.7% 2016-2022 CAGR for packaging versus 14.1% for devices. The first reason for this is that OSATs already have very low package margins due to fierce competition, and it will be difficult for them to lower the cost further. The second reason is the importance of testing. Because every MEMS is different, testing strategies are usually dedicated to one device type and account for a significant fraction of the final cost. The third reason is linked to the packaging’s material cost (i.e. gold and copper), which follows the global cost of raw materials. And the fourth reason is the strong CAGR for certain devices, for example RF MEMS.

IDM VS. OSAT: WHICH ONE WILL ENJOY A BIGGER SLICE OF CAKE?

Depending on the type of MEMS, either IDMs or OSATs oversee packaging. Today, OSATs own 55% of the MEMS packaging market’s value, while IDMs own 45%. The exact breakdown depends on the MEMS device type. In general, internal tests are conducted by IDMs since functional tests are very
MEMS packaging already has innovative approaches like TSV and open-cavity packages to expose a die to the outer environment (suitable for TPMS, humidity, temperature, gas sensors). And in the long-term, fan-out could also be used in some inertial MEMS and pressure sensors.

Packaging platforms will follow a steady evolution, with changes in the complexity of the existing platforms responding to the growing needs of sensor fusions. Combining several inertial or several environmental sensors in a package is now a reality, and the next step will be to combine inertial and environmental sensors in the same package, similar to how LEDs and photodiodes are integrated today. Thus, the MEMS packaging roadmap will need to integrate the shift from single-die packaging to multi-die packaging.

For automotive applications, packaging and assembly are even more important and could represent an opportunity for OSATs. Automotives tests require dedicated equipment and may be an interesting opportunity for ATE equipment suppliers. Besides packaging trends, Yole Développement analyzed the test strategy of IDMs and OSATs. Test equipment suppliers are improving testing tools with the implementation of parallel tests for numerous devices, adding new features (i.e. wafer-level tests for known-good die selections) as the big driver for reducing cost.

Yole Développement and System Plus Consulting have combined their MEMS and packaging expertise to offer a comprehensive report filled with detailed information. Our MEMS Packaging 2017 report comes with a complementary report from System Plus Consulting that includes a MEMS packaging review and a packaging teardown analysis of MEMS devices.
COMPANIES CITED IN THE REPORT (non exhaustive list)

TABLE OF CONTENTS
Introduction 4
What’s new since our last report? 6
Companies cited in this report 7
Executive summary 8
Introduction to the packaging industry 38
Introduction to the MEMS industry 42
MEMS packaging market forecast, 2016 - 2022 50
> Global units forecast
> Global revenue forecasts
> Revenue forecasts breakdown by
> Wafer-level and thin-film capping
> Interconnections
> Package and substrate
> Assembly
> Tests
MEMS packaging supply chain 96
> Key players
> OSAT roadmap
MEMS packaging focus, by device type 105
> Accelerometer
> - Market overview
> - Key players’ market share
> - Specific packaging and test requirements
> - Cost structure analysis
> - Supply chain
> - Packaging roadmap
> Gyroscope
> Magnetometer
> IMU
> Microbolometer
> Micromirror
> Pressure sensor & TPMS
> Gas sensor
> Silicon microphone
> Fingerprint sensor
> RF filter (BAW type)
> Antenna tuner
> Oscillator
Technology challenges & roadmaps 180
> Interconnection challenges and opportunities
> - Wirebond
> - Bumps
> - TSV
> - Hermetic solution challenges and opportunities
> - Ceramic package and metal lids
> - Getter solutions
> - Wafer-level packaging
> Analysis of market-specific requirements
> related emerging packaging types
> - Automotive
> - Consumer
> - Medical
> - Telecom and Industrial
> - Aerospace & Defense
MEMS testing and calibration 203
> Focus on MEMS wafer testing
> Focus on MEMS final test & calibration
Conclusions & perspectives 205
Author biographies 206

RELATED REPORT
Benefit from our Bundle & Annual Subscription offers and access our analyses at the best available price and with great advantages

REPORT OBJECTIVES
• Offer an understanding of the various MEMS markets’ dynamics
• Provide a forecast in units and value for the different packaging platforms, by MEMS device
• Discuss trends concerning MEMS packaging’s future
• Furnish insights regarding the MEMS packaging supply chain and the roles of IDM vs. OSAT
• Highlight MEMS testing trends

AUTHORS
Emilie Jolivet is a Technology & Market Analyst, in the Advanced Packaging and Semiconductor Manufacturing team, at Yole Développement, the "More than Moore" market research and strategy consulting company. She holds a master's degree Applied Physics specialized in Microelectronics from INSA Toulouse. After an internship in failure analysis in Freescale, she took the position of R&D engineer for 7 years in photovoltaic business and co-authored several scientific articles. Strong for this experience, she graduated from a master in Business Administration at IAE Lyon and then joined EV Group as a business development manager in 3D & Advanced Packaging before joining Yole Développement in 2016.

Dr. Eric Mounier has a PhD in microelectronics from the INPG in Grenoble. He previously worked at CEA LETI R&D lab in Grenoble, France in marketing dept. Since 1998 he is a cofounder of Yole Développement, a market research company based in France. At Yole Développement, Dr. Eric Mounier is in charge of market analysis for MEMS & Sensors, IR imagers and photonics (e.g. Silicon photonics). He has contributed to more than 200 marketing & technological analysis and 100 reports. Eric is also an expert at the OMNT (“Observatoire des Micro & Nanotechnologies”) for Optics.

Find all our reports on www.i-micronews.com
ORDER FORM
MEMS Packaging 2017

BILL 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

BY CREDIT CARD

☑ Visa  ☐ Mastercard  ☐ Amex

Name of the Card Holder:

Credit Card Number:

Card Verification:

Value (3 digits except AMEX: 4 digits):

Expiration date:

BY BANK TRANSFER

BANK INFO: HSBC, 1 place de la Bourse, F-69002 Lyon, France,
Bank code: 30056, Branch code: 00170
Account No: 0170 200 1565 87,
SWIFT or BIC code: CCFRFRPP,
IBAN: FR76 3005 6001 7001 7020 0156 587

RETURN ORDER BY

• FAX: +33 (0)472 83 01 83
• MAIL: YOLE DÉVELOPPEMENT, Le Quartz,
  75 Cours Emile Zola, 69100 Villeurbanne/Lyon - France

SALES CONTACTS

• North America - Steve Laferriere: +1310 600 267
  laferriere@yole.fr
• Europe & RoW - Lizzie Levenez: + 49 15 123 544 182
  levenez@yole.fr
• Japan & Rest of Asia - Takashi Onozawa: +81 3 6869 6970
  onozawa@yole.fr
• Greater China - Mavis Wang: +886 979 336 809
  wang@yole.fr
• Specific inquiries: +33 472 830 180 – info@yole.fr

*One user license means only one person at the company can use the report.

I hereby accept Yole Développement’s Terms and Conditions of Sale.

Signature:

ABOUT YOLE DEVELOPPEMENT

Founded in 1998, Yole Développement 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 and well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide covering MEMS and image sensors, Compound Semiconductors, RF Electronics, Solid-state lighting, Displays, software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Nanomaterials, Power Electronics and Batteries & Energy Management. The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and KnowMade, support industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

CONSULTING AND ANALYSIS

• Market data & research, marketing analysis
• Technology analysis
• Strategy consulting
• Reverse engineering & costing
• Patent analysis
• Design and characterization of innovative optical systems
• Financial services (due diligence, M&A with our partner)

More information on www.yole.fr

REPORTS

• Market & technology reports
• Patent investigation and patent infringement risk analysis
• Teardowns & reverse costing analysis
• Cost simulation tool

More information on www.i-micronews.com/reports

CONTACTS

For more information about:

• Consulting & Financial Services: Jean-Christophe Eloy (eloy@yole.fr)
• Reports: David Jourdan (jourdan@yole.fr) Yole Group of Companies
• Press Relations & Corporate Communication: Sandrine Leroy (leroy@yole.fr)

More information on www.i-micronews.com
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 Yole’s Terms and Conditions of Sale” by email or fax 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:

2.1.1 Production date:

- within 15 months from the order for Products already released;
- with a maximum of 30 days from the date of the original download or receipt of the Product.

2.4. The mailing is operated through electronic means either by email or on line the reports on I-micronews.com. In this respect, the Buyer cancels the order in whole or in part or postpones the delivery date. Any replacement is excluded for any event as set forth in article 3.

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 faults of delivery must be made by the Buyer within 2 days from the date of delivery. In this case, the Seller shall be entitled to have the Products checked. The replacement is guaranteed for a maximum of 12 months from the date of delivery. Any replacement is excluded for any event as set out in article 3.

2.6. In the event of breach by one Party under these conditions for any technical reason, the non-breaching Party shall be entitled to terminate the contract immediately.

7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part or postpones the delivery date, the Buyer shall indemnify the Seller for all 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 consequences their enforcement.

8. MISCELLANEOUS

8.1 All the provisions of these Terms and Conditions shall be enforced by the Buyer and the Seller and their respective directors, managers, officials and agents. Each of them is entitled to assert and enforce these provisions against the Buyer. Any variation under these Terms and Conditions shall be in writing. They shall be effective upon receipt by the other Party.

9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out of or connected to these Terms and Conditions or to the application of all or part of these Terms and Conditions shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.