GLASS SUBSTRATE FOR SEMICONDUCTOR APPLICATIONS 2020

Market & Technology Report - November 2020

The glass substrate market has $200M revenue today and will triple over the next five years, driven by Fan-Out Wafer Level Packaging (FO WLP), CMOS Image Sensors (CIS) and microfluidic devices.

WHAT'S NEW

- Status of the glass substrate industry and evolution
- Update of our 2019-2025 glass material market forecast segmented by semiconductor device and by glass functionality
- New analysis based on the competitive landscape and market share of the glass material suppliers by semiconductor segment covered in the report
- Key technical insights and detailed analysis of the glass material solutions, trends, requirements and challenges by semiconductor device and by functionality

KEY FEATURES

- Detailed analysis of glass substrates used in the following applications and devices: MEMS actuators and sensors, CMOS image sensors, memory and logic, RF devices, power devices, photonic components, microfluidic and FO WLP package
- Detailed analysis of glass substrates used into different functionalities: glass-based including permanent substrate, wafer level capping, TGV interposer, wafer level optics, IR cut-off filter, and glass carriers
- Glass substrate market metrics in wspy or panel and value for 2019-2025
- Breakdown by end-application, by functionality and by substrate size
- 2019 global glass substrate market share in the field of semiconductor
- 2019 glass material market share by application
- Overview of the players using glass material by application and functionality
- Technology roadmap for glass technology adoption
- Updated technology trends analysis across different semiconductor segments
- Detailed study of the glass substrate opportunity in the field of semiconductor with cost, technology, and supply chain status

GLASS IS A VERSATILE MATERIAL APPLIED IN DIFFERENT FUNCTIONALITIES IN THE FIELD OF SEMICONDUCTOR APPLICATIONS

Glass is a common material already employed in everyday applications, including windows, eye glasses, and bottles.

Over the last few years, glass has gained considerable interest for electronic components, due to its very attractive electrical, physical, and chemical properties, as well as its prospects for a relevant, cost-efficient solution.

As of today, the application scope of glass substrates in the semiconductor field is broad and highly diversified.

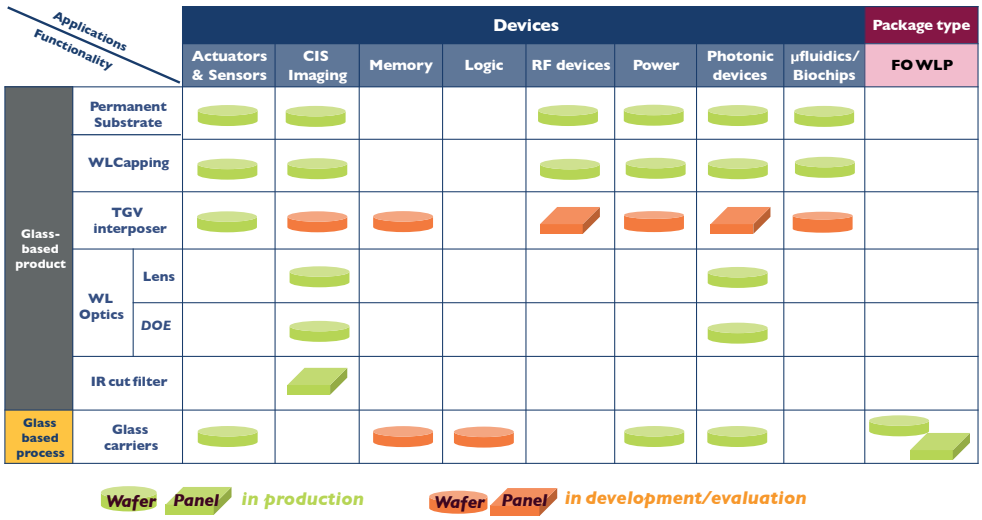
Glass material can adopt various functionalities within Integrated Circuit (IC) and semiconductor devices, such as MEMS actuators and sensors, CMOS Image Sensors (CIS), memory and logic, Radio Frequency (RF), power electronics, photonics, microfluidics devices as well as the Fan Out Wafer Level Packaging (FO WLP) technology platform. It can be used in the following ways:

- Permanent support glass substrates that undergo many fabrication process steps, such as etching, deposition of materials and photolithographic patterning
- Wafer Level Capping (WLCapping), which is based on mechanical sawing of a wafer cap above the sensor
- 3D TGV/Glass interposer, referring to a structure integrating vertical through via electrical connections from top to underside, Through Silicon Vias (TSVs) for interposers or Through Glass Vias (TGV) for glass interposers
- Wafer Level Optics (WLOptics) split into two main wafer-level elements
  - Refractive optical elements based on lenses structures so-called Wafer-Level-Lenses
  - Diffractive Optical Elements (DOE) including microoptics for Augmented Reality (AR)
- Infra Red (IR) cut-off filters processed on panel substrates, whose role is to keep IR away from CMOS devices that are sensitive to it
- Glass carriers used as temporary substrates to provide mechanical support for the thin silicon device wafers

The demand for glass today is mostly driven by WLCapping and glass carriers, fueled mostly by MEMS, CIS and FO WLP. In the coming years, the availability of other glass functionalities such as TGV interposers, still perceived as immature, in conjunction with end-applications like RF devices, could be the driving force for growth. This will create new challenges and new technical developments along the way.

This report provides a detailed overview of glass functionalities and platforms, as well as the various end-applications it is relevant for.

2019 Glass substrate functionalities vs semiconductor devices



(Yole Développement, November 2020)

GLASS MARKET REVENUE WILL TRIPLE OVER THE NEXT FIVE YEARS, DRIVEN BY FO WLP, CIS AND MICROFLUIDIC DEVICES

Glass substrate revenue reached almost $196M in 2019 and is expected to exceed $580M by 2025, mainly supported by FO WLP packages, WLOptics, actuators, MEMS actuators and sensors.

Initially driven by CIS and MEMS applications, this growing industry will be supported by relevant end-applications such as microfluidics and FO WLP, where glass will further penetrate. Commercialization will be helped by increasing demand from photonics, memory and logic devices.

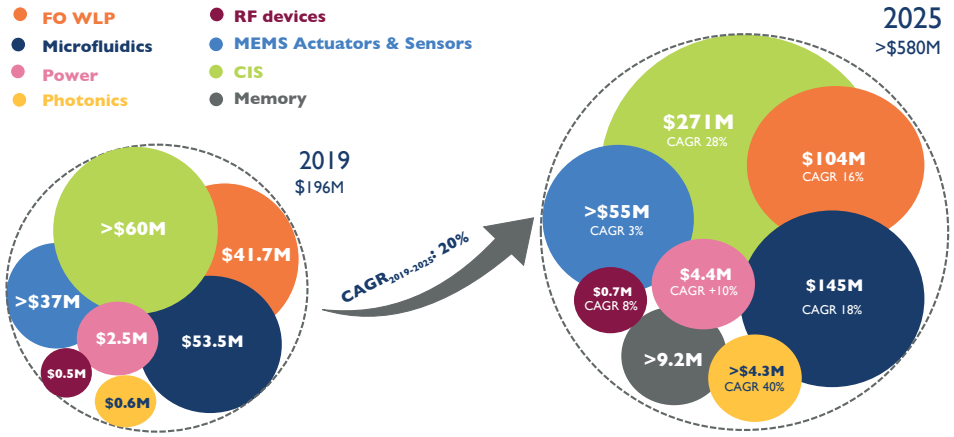
With a Compound Annual Growth Rate (CAGR) of 40%, the use of glass material for photonics will be glass's fastest-growing field over the next five years due to the entrance of high-index material for waveguides dedicated to AR.

Additionally, RF devices and FO WLP will also provide nice niches with volume growth and a chance for any glass material supplier to penetrate the market. We expect an introduction of panel formats in those applications by 2023 for RF devices.

Moreover, memory applications will participate in the growth of the glass wafer market, driven by the adoption of glass carriers. Some memory manufacturers have already invested in laser debonding required for glass carriers. We expect that the time for qualification could last two years before mass production can begin. This brings the earliest possible date for glass carrier mass production for memory to early 2022.

Therefore, the use of glass will certainly be on the High-Volume Manufacturing (HVM) roadmap within a few years for other semiconductor applications.

2019 - 2025 Overall glass wafer market revenue for semiconductor devices



*Glass Panel for Semiconductor devices is not included in this chart but included in the report

(Yole Développement, November 2020)

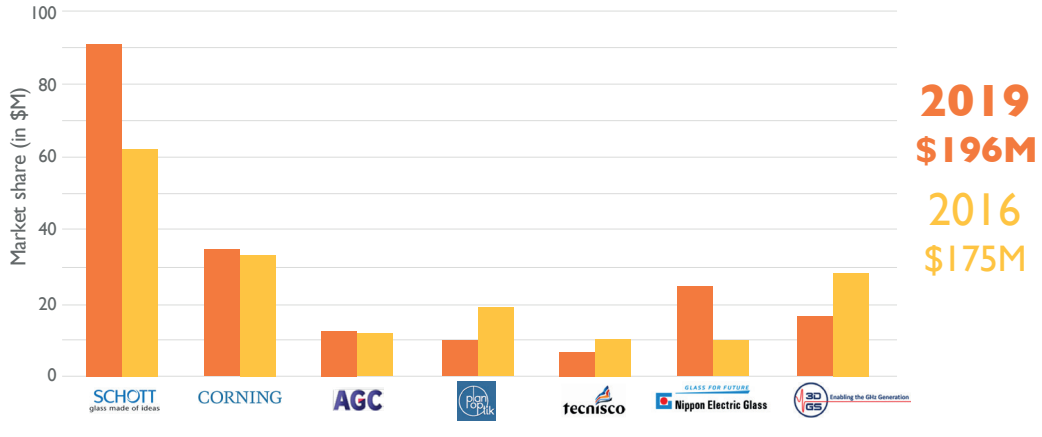
ALTHOUGH EMERGING GLASS APPLICATIONS COULD RESHAPE THE GLASS SEMICONDUCTOR INDUSTRY, THE COMPETITIVE LANDSCAPE HAS REMAINED ALMOST THE SAME OVER THE LAST FEW YEARS

Nowadays, the number of glass vendors able to deliver wafers and panels with the specifications the industry needs is quite limited.

The top two players, Schott and Corning, are still leading the glass material market. For the last few years they held more than 60% of the total glass wafer market.

Other glass raw material and glass wafer processors vendors such as NEG, AGC, PlanOptik and Tecnisco have captured share in this market.

2019 vs 2016 Glass wafer market share for semiconductor devices*



*Non-exhaustive list of companies

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NEG's market share and business is coming from the FO WLP market since it is the leading supplier of TSMC for the integrated Fan Out (inFO) product. Planoptik's revenues account for the majority of the business for glass carriers for power applications due to its relationship with Infineon in actuator MEMS pressure sensors using WLCapping.

Although Corning and AGC are really active in the RF front-end and connectivity industries with their borosilicate products, the RF industry is also evaluating photosensitive glass material mostly offered by 3D glass solutions. Its solution could be an alternative solution for RF high frequency applications due to high thermal performance combined with low-cost manufacturing.

There are still business opportunities in this immature market that are not really well established. They could reshuffle the ranking by inviting specialized glass vendors with well-honed expertise in specific applications to enter. The level of performance and the cost will determine the winner.

Competitive landscape and major key glass material suppliers' market share are quantified by application and detailed in this report.

COMPANIES CITED IN THE REPORT (non exhaustive list)

3D Glass solutions, 3D micromac, 3M, Array it, Agilent Technologies, AGC, Amkor, AMS (Austria Microsystems)/Heptagon, Anteryon, ASE Group, Biel Crystal, Boehringer Ingelheim, Bosch, Bullen, Caliper (PerkinElmer Company), CDGM Glass, Coherent/Rofin, Corning, Dolomite, EVG, Fujitsu, Fraunhofer IZM, Georgia Tech, Himax, HOYA, Ibiden, Illumina, IMT MEMS, IMT AG, Infineon, Intel/ Lemeptix, Kiso Micro, Kulite, Lenovo, LensVector, LPKF, Luminex, Medimate Minilab, Micronics, Menlo Micro, Micron, Micronit technologies, Mimetras, Murata, Nanosphere, Nepes, Nippon Electric Glass (NEG), NSG Group, Ohara OPC, Omron, ON Semiconductor, Optopac, Pacific Biosciences, PlanOptik, Polight, Power Technology, Qualcomm/TDK Epcos, Saint Gobain, Samsung, Samtec, Schott, Sensata technologies, Sensirion, Shinko, Silicon Sensing, SK Hynix, SPIL, ST Microelectronics, STATSChipPAC, SUSS MicroTec, Sy&Se, Teledyne Dalsa/ Micralyne,Texas Instrument, TE Connectivity, Tecnisco, Tissuse, Translume, TSMC, Unimicron, Waveoptics, Wavelens, WLCSP, Xintec, YEK Glass and many more…

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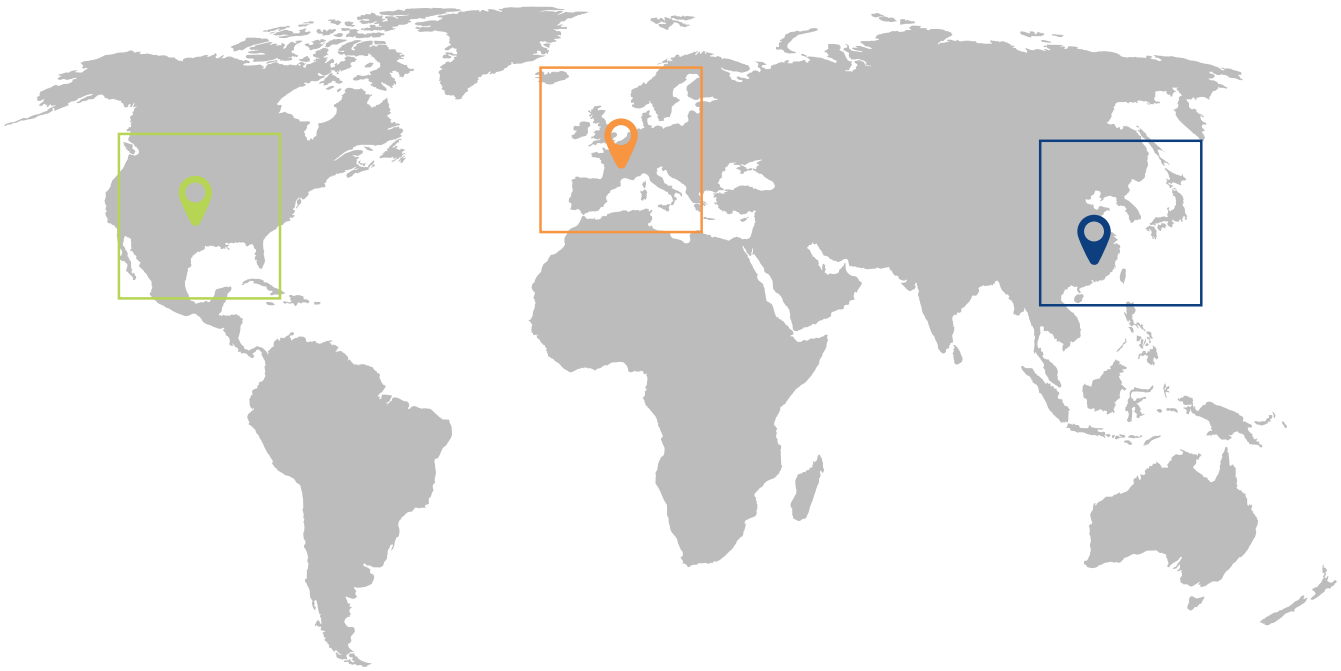
REPORT OBJECTIVES

The objectives of the report are to
- Provide a detailed analysis of the status of the glass material industry for:
  - Applications such as MEMS actuators and sensors, memory and logic, CIS, RF devices, power, photonics as well as microfluidic applications
  - Glass functionalities such as: permanent substrates, WLCapping, TGV interposers, WLOptics, IR cut-off filters and glass carriers
- Identify established applications and emerging applications using glass material substrates and provide their trends and drivers
- Give the current status of glass material adoption and the various type of glass materials available on the market
- Highlight the key glass technologies used in semiconductors
- Provide an overview of the technological trends for glass materials
- Understand the key benefits and added value of the glass materials in the field of semiconductors
- Review technical glass characteristics, challenges and barriers to entry for each market segment and functionality
- Offer market metrics at glass wafer market level for semiconductor applications for 2019-2025
- Evaluate market developments in terms of market size in volume and value, substrate sizes and formats
- Provide a competitive landscape, identify key players in technology development and manufacturing
- Give an overview of who is doing what, and details of each market

AUTHOR

Amandine Pizzagalli oversees the equipment and materials fields for the Advanced Packaging and Manufacturing team at Yole Développement. She holds an international MBA from IAE Lyon, School of Management (France) and an electronic engineering master's degree from the engineering school, CPE Lyon (France)m and another degree, focusing on semiconductor manufacturing technology, from KTH Royal Institute of Technology (Sweden). Prior to Yole Développement, Amandine worked for Air Liquide, with an emphasis on CVD and ALD processes for semiconductor applications.

CONTACT



Western US & Canada
Steve Laferriere - steve.laferriere@yole.fr
+ 1 310 600-8267

Eastern US & Canada
Chris Youman – chris.youman@yole.fr
+1 919 607 9839

Europe and RoW
Lizzie Levenez – lizzie.levenez@yole.fr
+49 15 123 544 182

Benelux, UK & Spain
Marine Wybranietz - marine.wybranietz@yole.fr
+49 69 96 21 76 78

India and RoA
Takashi Onozawa – takashi.onozawa@yole.fr
+81-80-4371-4887

Korea
Peter Ok - peter.ok@yole.fr
+82 1040890233

Japan
Miho Ohtake – miho.ohtake@yole.fr
+81 34405-9204
Toru Hosaka – toru.hosaka@yole.fr
+81 90 1775 3866

Japan and Singapore
Itsuyo Oshiba – itsuyo.oshiba@yole.fr
+81-80-3577-3042

Greater China
Mavis Wang – mavis.wang@yole.fr
+886 979336809 +86 136 61566824

Sales Coordination & Customers Service
David Jourdan – david.jourdan@yole.fr
+33 472 83 01 90
Fayçal El Khamassi – faycal.khamassi@yole.fr
+33 472 83 01 95

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CONTACTS
For more information about :
- Consulting & Financial Services: Jean-Christophe Eloy (eloy@yole.fr)
- Reports & Monitors: David Jourdan (david.jourdan@yole.fr) & Fayçal Khamassi (faycal.khamassi@yole.fr)
- Marketing & Communication: Camille Veyrier (camille.veyrier@yole.fr)
- Public Relations: Sandrine Leroy (sandrine.leroy@yole.fr)