STATUS OF ADVANCED SUBSTRATES 2019

Market & Technology Report - May 2019

Demands from the new digital age are waking up the sleeping substrate giants.

WHAT'S NEW

- FC BGA substrate capacity is running short in supply
- FC CSP is still growing, driven by DRAM
- New SLP applications other than smartphones
- Latest adoption of embedded die package
- Substrate manufacturers are switching to mSAP
- China consolidating its substrate manufacturing market

REPORT KEY FEATURES

- Advanced IC substrate with focus on FC CSP & BGA, and the impact of FO on these markets. Players, supply chain, roadmaps and forecasts with FC CSP/BGA and FO breakdown, market shares for each player
- SLP, with a focus on Huawei as a new user and for mobile, smartwatches and tablets. Players, supply chains, roadmaps and forecasts broken down by board type and application. New process flow overview
- Embedded die, with a focus on automotive, telecom and infrastructure markets. Players, supply chain, roadmaps and forecasts, broken down by market
- Financial analysis of top 10 substrate makers' revenue and net income
- China's environmental regulations and their impact on substrate manufacturing

THE ADVANCED SUBSTRATE INDUSTRY HAS STARTED TO INNOVATE TO KEEP UP WITH ADVANCED PACKAGING TRENDS

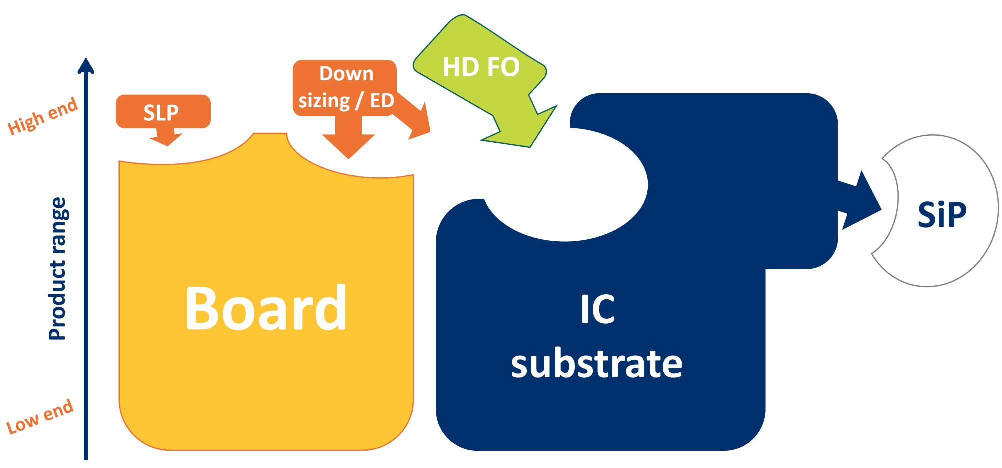
The integrated circuit (IC) substrate and board industry has historically assumed a passive role, especially when it comes to innovation. However, in the past few years, the landscape has become increasingly competitive. Industry players are looking to differentiate from others.

The advanced substrate industry is now following the trends of advanced packaging. Miniaturization, greater integration and higher performance are becoming mainstream in this industry. Huge investments by several players are ongoing for embedded die (ED) and substrate-like printed circuit board (SLP), showing the increased interest in such technology.

The substrate and printed circuit board (PCB) global market will record a modest compound annual growth rate (CAGR) of around 4% from 2018-2024. But, if we only consider advanced substrate technology as SLP and ED technology, they exhibit a much higher growth rate, up to 49% $CAGR_{2018\text{-}2024}$ for ED.

Flip Chip (FC), SLP and ED are gaining market share from the conventional board and IC substrate markets. That's especially true for SLP and ED, which have the capability to reduce either the board or IC substrate footprint. Undoubtedly, these technologies can address the integrational needs of applications in this new digital age, but bring complexity and demand innovation before production and adoption take place. In addition, such technology bring huge value into the market. Hence it is not surprising they are expected to fetch a higher average selling price (ASP) and better revenue. In this report, Yole Développement (Yole) will detail FC, SLP and ED trends and their usage in different markets and applications. Yole's analsyts will provide in-depth information about the markets, applications, numbers, roadmaps, players and supply chains.

Advanced substrate and packaging's impact on board and substrate markets

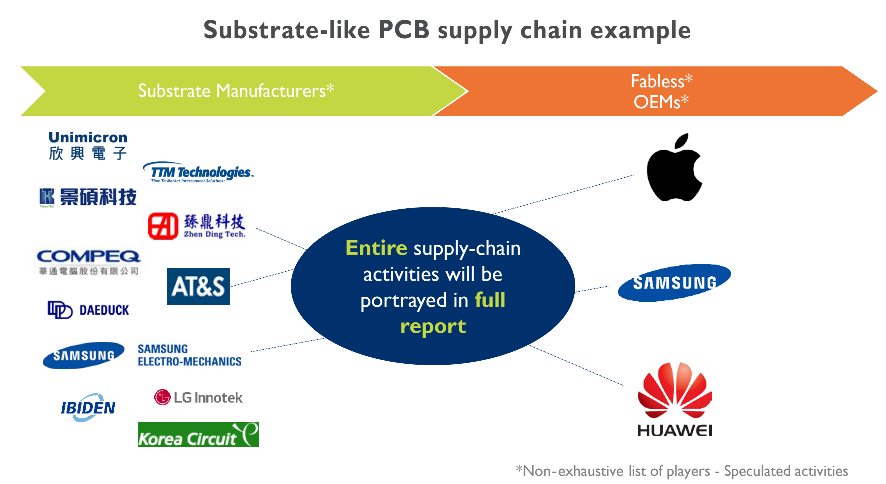


(Yole Développement, May 2019)

INCREASED SLP ADOPTION BY LEADING OEMS IS DRIVING MARKET GROWTH SIGNIFICANTLY

The global SLP market is valued at $987M in 2018 and is expected to grow through to 2024, driven by the global cell-phone market.

Presently, the SLP market is still heavily dependent on high end smartphone growth, particularly Apple iPhones and Samsung Galaxies. Moving forward, Huawei is expected to release high-end products with SLP technology in 2019. Furthermore, cell-phone-producing OEMs are planning to use SLP in other consumer electronic



(Yole Développement, May 2019)

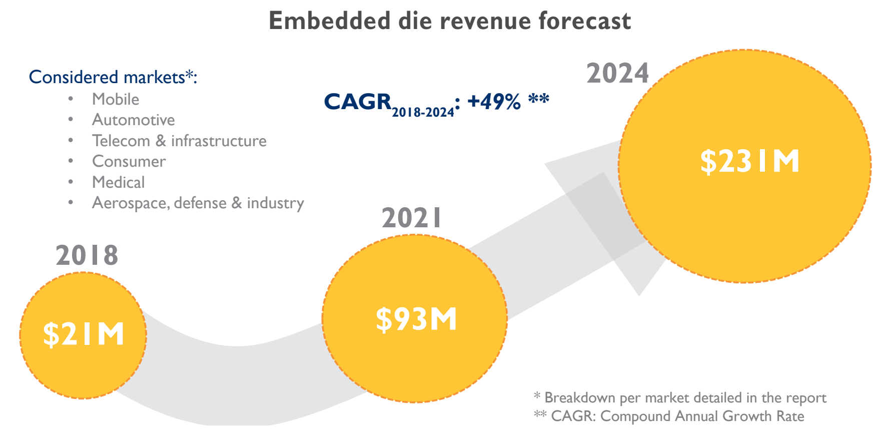
products like smartwatches and tablets. SLP will become more mainstream than ever before.

Currently, SLP manufacturers from Taiwan, South Korea and Japan are dominating production activities. Players like Japan-headquartered Meiko and Taiwan-headquartered ZD Tech are expanding new SLP production lines in Vietnam and China for more than one smartphone customer. Certainly, China will gain SLP technical know-how progressively with technology transfer from the major players.

In this report, Yole will share insights on SLP technology, markets, players and the supply chain. In addition, the team will also analyse the breakthroughs in SLP manufacturing and their impact on the supply chain.

EXCITING GROWTH OF EMBEDDED DIE OFFERS SUBSTRATE STACKING SOLUTION

ED is the first real substrate stacking technology on the market. Its market is valued at $21M in 2018 and is expected to reach $231M by 2024, exhibiting a 49% CAGR. This is the highest growth of all the advanced substrate platforms, and can be justified by an infant technology that will boom soon.



(Yole Développement, May 2019)

Yole has been studying ED technology since its early stages. Based on this expertise, we will be detailing the ED markets where mobile device makers were early adopters and will remain an important source of revenue.

We foresee a bright future for ED. Firstly, this is due to extended adoption in new automotive applications. It is also due to the telecom and infrastructure market where ED is a suitable solution to increase hardware efficiency. Secondly, players are investing huge amounts in new plants where ED will be the main product. Supported by major OEMs, Yole believes that an ED market boost will occur in the next two years.

Nowadays, there are many players active in ED research and development, but only a few have jumped into high volume manufacturing (HVM). Based on the technology, markets dynamics, and investments detailed in this report, Yole believes that, in the near future, more players will enter ED HVM and contribute to the adoption of this technology.

REPORT OBJECTIVES

- Show the impact of the global semiconductor market trend on the substrate manufacturing
- Outline three advanced substrate platforms: Advanced IC substrates, substrate-like PCB and embedded die
- Provide an overview of the markets trends and drivers pushing the innovation in substrate manufacturing
- Update market data and forecasts for the three advanced substrate platforms
- Describe the markets and key applications that are using/will use such advanced substrate solutions
- Identify the main players and supply chain for advanced substrate manufacturing
- Predict future applications where technology such as SLP and ED can be adopted

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Prior to Yole, Mario was engaged in test activities development on LEDs at Aledia. He was also in charge of several R&D advanced packaging programs. During his five-year stay, he developed strong technical and managerial expertise in different semiconductor fields.

Mario holds an Electronics Engineering Degree from Polytech' Grenoble, France. He apprenticed for three years in the Imaging division of STMicroelectronics Grenoble, where he contributed to test bench park automation within the test and validation team.

Favier Shoo is a Technology and Market Analyst in the Semiconductor and Software division at Yole Développement, part of Yole Group of Companies. Based in Singapore, Favier is engaged in the development of technology and market reports as well as the production of custom consulting.

After spending 7 years at Applied Materials as a Customer-Application-Technologist in advanced packaging marketspace, Favier had developed a deep understanding of the supply chain and core business values. Being knowledgeable in this field, Favier had given trainings and held numerous technical review sessions with industry players. In addition, he had obtained 2 patents. Prior to that, Favier had worked at REC Solar as a Manufacturing Engineer to maximize production capacity.

Favier holds a Bachelor in Materials Engineering (Hons) and a Minor in Entrepreneurship from Nanyang Technological University (NTU) (Singapore).

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The present document is valid 24 months after its publishing date: May 9, 2019

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