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The Future of Semiconductor Packaging

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The future is bright for semiconductor industry growth

CSR asked Asif R. Chowdhury, SVP, UTAC Group, to share his insights on semiconductor industry growth trends and the current supply chain constraints.

CSR: You are rather bullish on the prospects for the semiconductor industry to see double-digit year-over-year (YoY) growth for the second half of this decade. Could you highlight those developments that you believe will lead to this growth projection?

(**Figure 1**). I predict that this growth will be driven by the convergence of certain fundamental technologies such as 5G mmWave communications, which will enable connectivity at about 100 times faster than what we have today. We are now beginning to experience a higher level of maturity of artificial intelligence (AI), virtual and augmented realities (AR/VR) and cloud computing. These technologies will get a significant boost from the faster, smoother, and ubiquitous connectivity of 5G mmWave—this is what I am calling

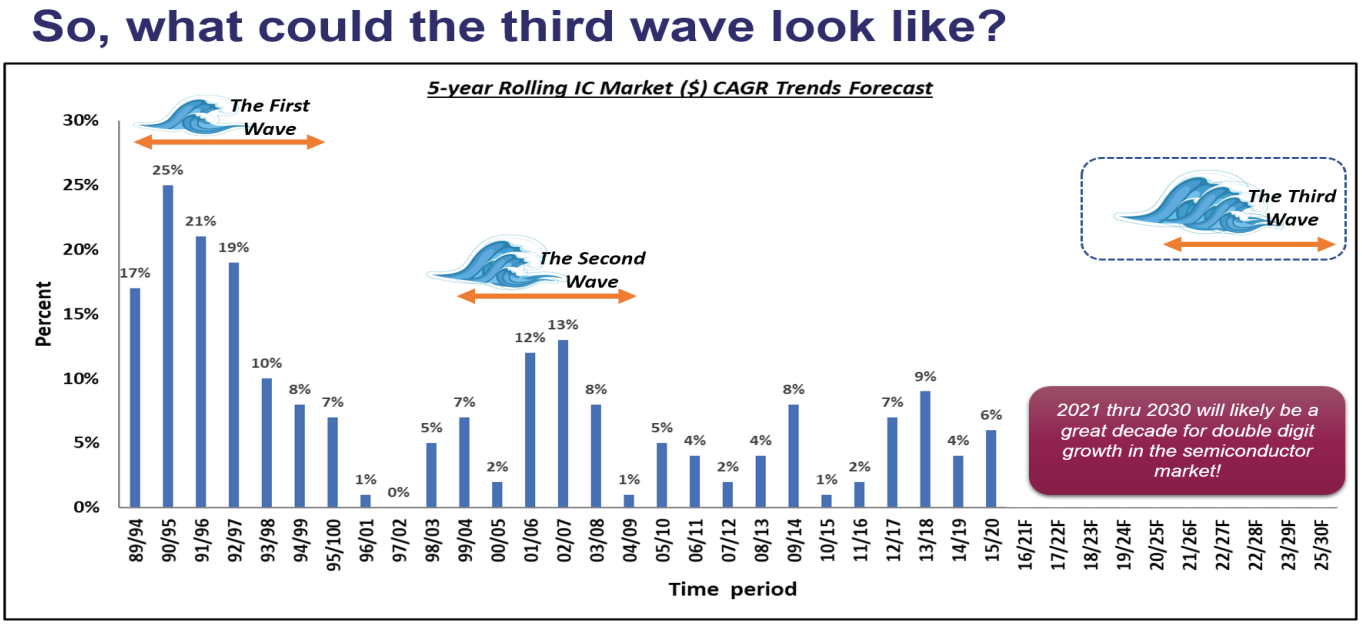

Figure 1: 5-year rolling IC market ($) CAGR trends forecast. SOURCE: Asif Chowdhury, UTAC

AC: While the semiconductor sector accounts for only 0.5% of global gross domestic product (GDP), I think people and governments all over the world are coming to the realization that a significant portion of the remaining 99.5% of the GDP is dependent on it. It is telling when one sees the U.S. president holding a wafer and talking about the importance of semiconductors-–frankly, this was the first time for me to witness such a thing in my thirty plus years in the industry. Indeed, I do believe that we have another golden era of the semiconductor industry upon us with significant growth potential this decade, especially in the second half

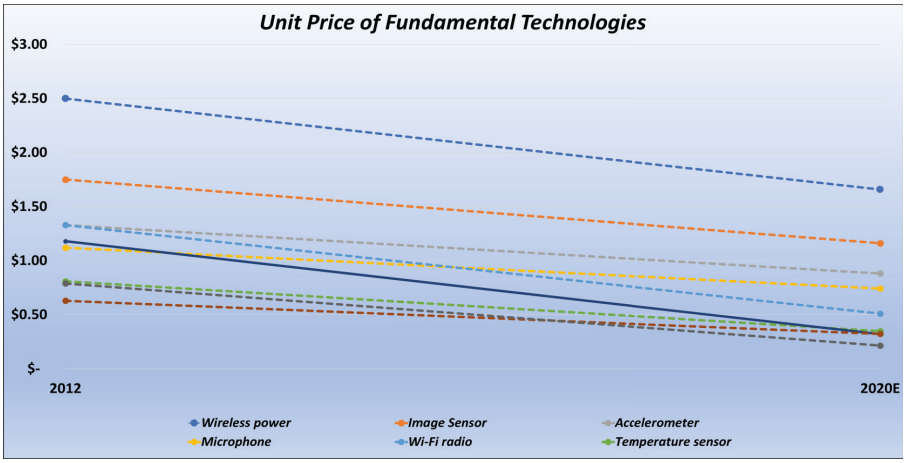

Figure 2: Unit price of fundamental technologies. SOURCE: Asif Chowdhury, UTAC

the technology convergence. In parallel, the price points of certain enabling semiconductor technology nodes such as microelectromechanical systems (MEMS) and other key sensors, converters, microcontrollers, image sensors, Bluetooth® and other wireless radios, have come down during the last decade (**Figure 2**). The technology convergence along with the affordability finally make the Internet of Everything (IoT) a reality. It will also enable the proliferation of full autonomous vehicles within this decade. Semiconductors are at the heart of all of these technologies and this convergence will drive what I call the third wave of semiconductor growth.

CSR: While you see a bright future for growth later this decade, please summarize how UTAC has been handling the current supply constraint challenges that have arisen during the global pandemic response.

AC: Perhaps this current imbalance of supply and demand of semiconductors is a glimpse into the future growth and demand for semiconductors through this decade. The entire semiconductor industry was caught off guard with the demand significantly outstripping the supply that started since last year, and all of us are still struggling with this issue. We are working very closely with all our partners and stakeholders, both on the supplier and customer sides.

We see the shortage and limitation on the supply side across the board starting from raw materials, to wafers, to substrates and to overall manufacturing capacity. Frankly speaking, there is not much anyone can do about these shortages in the short term. So, the key is to "manage" this predicament that no one, unfortunately, foresaw. The way we are handling this crisis (I think the word "crisis" is apt) is through open, honest and regular communications with both our suppliers and customers. We are working closely with our customers to understand the "true" demand. In some cases, we are asking them to prioritize the demand based on the supply shortage. While they are not happy, I must say that most customers are quite understanding and cooperative as long as the communication remains regular and open. Similarly, we are

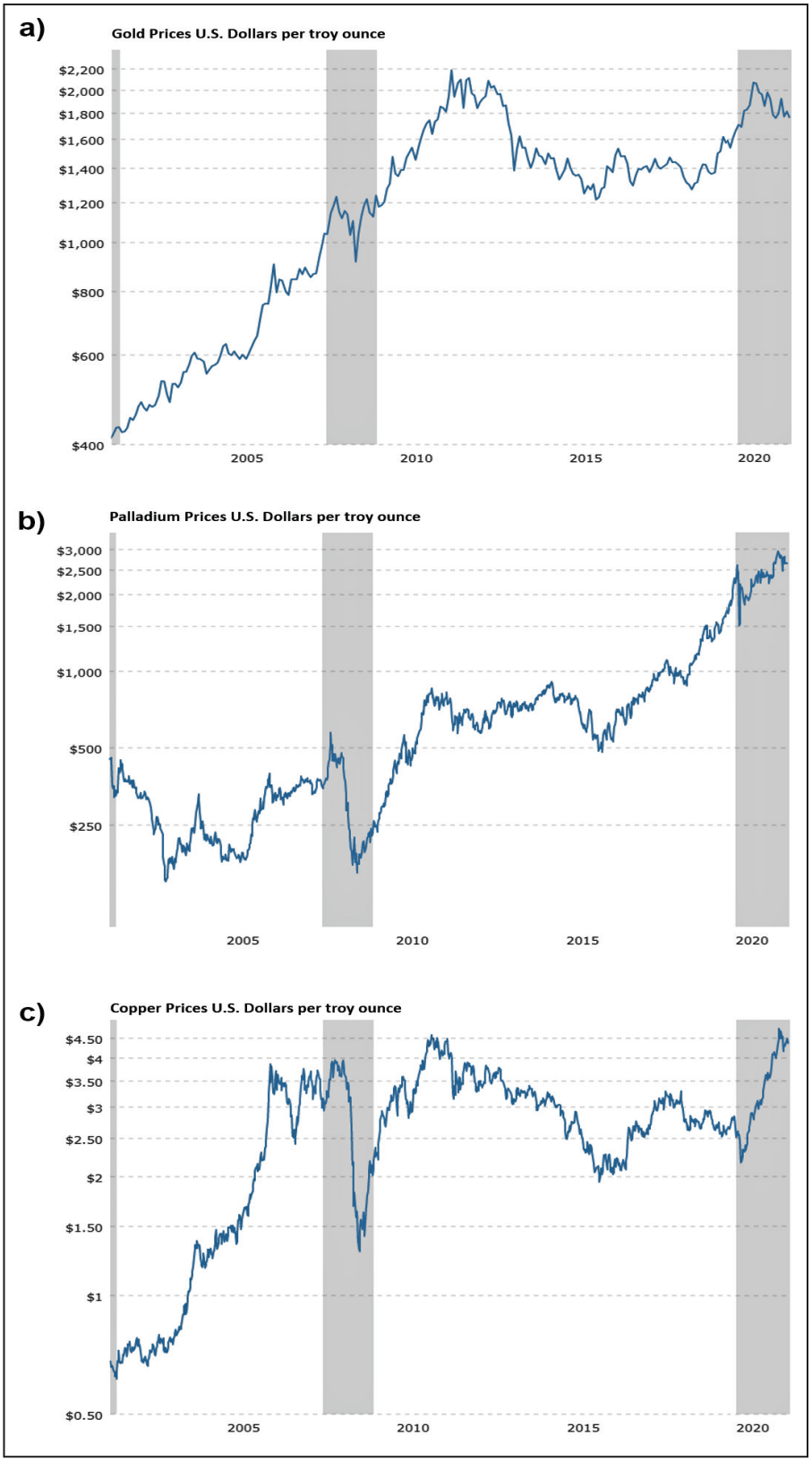

Figure 3: Historical prices of: a) gold; b) palladium; and c) copper. SOURCES: [1-3]

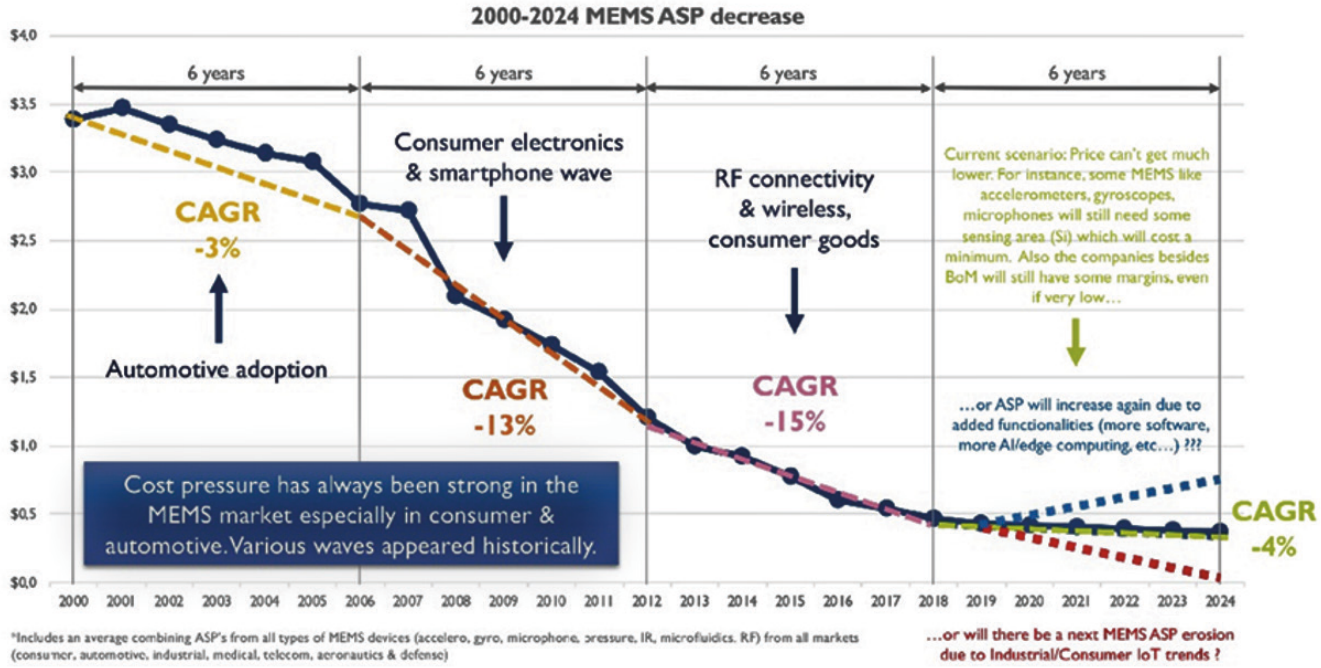

Figure 4: MEMS average selling prices (ASP) evolution. SOURCE: "Status of the MEMS Industry" report, Yole Développement, March 2020

communicating with our suppliers based on this "true" customer demand and ensuring that they keep us posted on their constraints on raw materials and capacity. We have customers signing long-term agreements that provide the ability to do long-term forecasting. These binding agreements reflect realistic forecasts and prevent the market from intentionally inflating future demands. It is not an easy problem to navigate, and our management team is being vigilant in addressing this crisis on a daily basis. Perhaps one silver lining of this predicament is that finally, we are seeing an appropriate upward adjustment of prices based on the market value across the supply chain (**Figure 3**). I think people are realizing that year after year of price reductions, especially against the headwind of increasing raw material prices, is simply not sustainable.

CSR: How will cost competitiveness drive the development of novel advanced packaging solutions?

AC: The cost competitiveness of semiconductors will continue to be a very important factor in the proliferation of these technologies, especially now with the increasing cost of certain raw materials, as well as increasing labor costs in certain markets. As most of your readers are aware, the hype of IoT never materialized during the last decade. In my opinion, it has a lot to do with relatively higher overall product costs. So, unless new semiconductor products and the packaging solutions are cost competitive, they will not likely be successfully adopted by the broader market.

From a product perspective, MEMS is a good example of how the industry has successfully driven the cost down over the last twenty years, most of which was driven by the cost reduction effort in packaging technology. **Figure 4** shows this historical cost reduction. MEMS are one of the most critical products that has not only taken automotive safety to a whole new level during the last two decades, but are critical for many IoT products because these sensors digitize our senses: what we see, feel and touch. The cost of MEMS has significantly been driven down both through device-level advancements and novel packaging solutions—moving away from expensive ceramic packaging to lower cost laminate cavity packaging, or even more mainstream over-molded packaging solutions in some cases. We will see similar trends across most key product segments.

We are already witnessing wider adoption of some of the new packaging and process platforms that are driving down costs. Multi-layer lead frame packages, such as molded interconnect system (MIS), have started to compete with costlier land grid array (LGA) and ball grid array (BGA) counterparts, at least in products with relatively lower I/O counts. We are also witnessing the growth of our own multi-row quad flat no-lead packages (QFNs), known as GQFNs, directly competing with laminate solutions both for cost and performance reasons. I believe that we will soon see large panel-level solutions for some of the lead frame-based packages; if this is successful, the cost will come down significantly. Obviously, there is quite a bit of work going on to improve the yield and cost of existing 600x600mm panel-based solutions for fan-out wafer-level chip-scale packaging (WLCSP) and for multi-die integration. We are also starting to

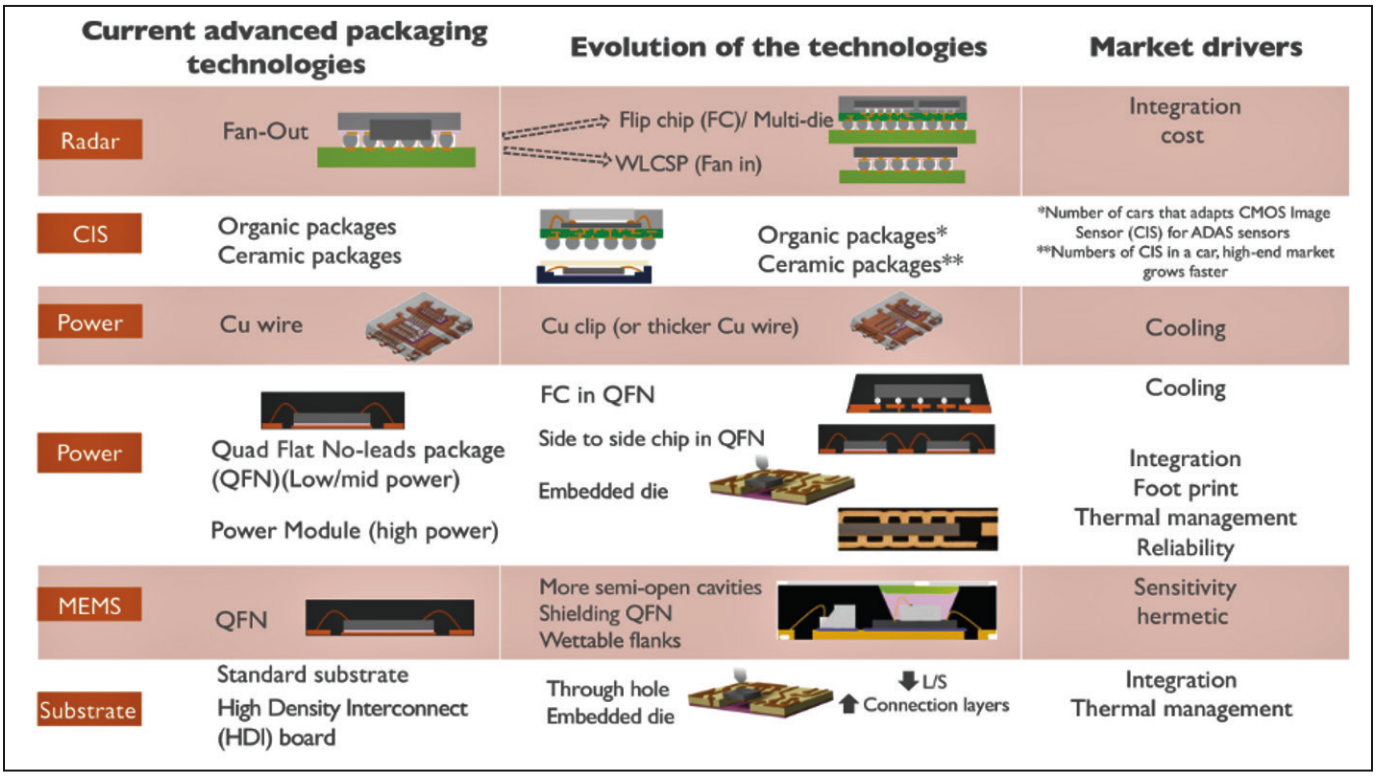

Figure 5: Automotive packaging roadmap. SOURCE: Yole Développement

see customers showing interest in our plasma dicing solution, which enables a very narrow scribe street, thereby allowing a dramatic increase in die per wafer, especially for smaller die sizes. For mature wire bond packages, there has been a steady migration from gold wire to copper wire during the past two decades, and we will continue to see this trend. So, cost will continue to be a key factor in developing new packaging solutions going forward.

CSR: How will the proliferation of multi-die package-level integration come to fruition?

AC: We will likely witness significant growth in system-in-package (SiP) solutions during this decade. It is not just SiP—there will be a proliferation of multi-die solutions in various package types. We are already seeing multi-die requirements from a broad customer base in standard QFN and system on integrated chips (SOIC)-type packages, as well as in more advanced laminate-based BGA solutions. Many of the multi-die solutions in standard mainstream packages will be driven by various products for wider IoT applications such as smart homes. Perhaps a good example of this can be seen in the automotive packaging roadmap by Yole Développement (**Figure 5**). The roadmap rightfully predicts multi-die package and SiP solutions across the product spectrum for the automotive market. Complex, but cost-effective SiP packaging solutions, are now being developed for radars, especially solid-state light detection and ranging (LIDAR) products—a key enabling technology for autonomous vehicles. For power products, we are now witnessing the slow yet steady proliferation of multi-die, multi-Cu clip types of QFNs. Even for standard packages such as quad flat pack (QFP) packages, workhorse of the automotive industry, we are seeing a demand for multiple die solutions. Similarly, driven by both cost and real estate, we will see multi-die and SiP solutions for other semiconductor products for various applications across market segments. I think the decade of SiP is here.

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Biography

Asif R. Chowdhury is SVP at UTAC Group, Singapore. He has over 30 years of experience in the semiconductor industry. Before joining UTAC, he held senior positions at Amkor Technology, Chandler, AZ, and Analog Devices, Wilmington, MA. He holds a BS in Mechanical Engineering from U. of Texas at Arlington, an MS in Mechanical Engineering from Southern Methodist U., and an MS in Finance and an MBA from Northeastern U. Email asif_chowdhury@utacgroup.com