Maximizing the 'value-add' of the electronic materials partner

Consumer devices are driving a significant portion of today's electronics industry growth. These new markets are both exciting and challenging for IDMs (Integrated Device Manufacturers) and OEMs (Original Equipment Manufacturers). They are dynamic and usually more difficult to predict and forecast than business-to-business markets. Short time-to-market and fast ramps to high yielding production are especially key to success. IDMs, OEMs and their partners also face other challenges. Increasingly feature rich devices packed into smaller form factors drive complex design and manufacturing challenges. Competition and cost-pressures have driven trends of outsourcing to reduce development and manufacturing costs in order to focus precious resources on improving their core competencies. Geographical production shifts have introduced new communication, logistical and coordination challenges. Shorter times-to-market require that technical obstacles and design trade-offs be identified early and resolved quickly. Traditional roadmap approaches to industry collaboration for technology development are useful but can have limitations in driving communication and collaboration across multiple levels of the electronics supply chain. Early involvement of value-add partners leading to co-development is suggested.

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Today's industry challenges

Consumer devices have become a major growth engine for the electronics industry. This creates a new set of challenges for an industry whose structure has dramatically changed over the past ten years. Consumer markets are more unpredictable in terms of forecasting compared to the relatively more stable and understood performance and volume requirements of business-to-business end markets such as business PCs and servers. Because consumer purchases are more emotional, the next 'hit' product and its combination of features and form-factor are less predictable. This creates a demand to rapidly conceive and bring new product designs to market and - if you have a 'hit' - be prepared to ramp production quickly with high yielding processes and minimal levels of inventory.

On the technology side, ever smaller components packed with new features and functionality are being produced. Approaches to meet such demands in the semiconductor world can include more functions in a single chip (system-on-chip or SoC); multiple chips inside one package (system-in-package or SiP); and package stacking (package-on-package or PoP). This creates significant technical challenges for design and manufacturing which impact all parts of the supply chain. There are also non-technical issues to deal with such as intellectual property and business models when combining chips or design IP from several sources within one package (SiP) or device (SoC).

Figure 1. Market Drivers and Technical Trends.

These challenges are further complicated by today's global industry infrastructure. Beginning in the 1990s the electronics industry has exhibited signs of maturing as cost pressures have forced a 'de-verticalization' of the supply chain structure. Market forces have incentivized OEMs and IDMs to increasingly rely on outsourcing to reduce costs and focus precious internal resources on the advancement of core competencies. Today's supply chain involves layers of SATS (Semiconductor Assembly & Test Services), EMS (Electronic Manufacturing Services), CEMS (Contract Electronic Manufacturing Services) and ODM (Original Design Manufacturing) companies and has become more compartmentalized as each layer optimizes its own business in the battle to maintain profitability. The relentless pressure to reduce costs has also driven component manufacturing and systems assembly to new regions. The bottom line result of these changes in industry structure is a supply chain structure that is inherently challenged by the fast-track projects demanded by today's consumer markets.

OEMs plan and design new products targeted at fickle consumers in markets where product life cycles are often measured in months. To generate a successful return on the investment in new products the OEM must integrate complex features yet meet low market price points, introduce the product within narrow market windows and meet the demand ramp efficiently and cost-effectively. Given today's compartmentalized supply chain structure one approach to improve the total supply chain performance is through stronger communication and collaboration across its multiple levels and also between members operating within each level. The more the IDMs and OEMs involve their supply chain partners early in the product design process, the more they may anticipate and avoid problems in manufacturing and performance.

Co-design and co-development can help get to the best overall solution faster, less expensively and at lower risk than working independently or in a serial sequence of design to development to manufacturing. Members of the supply chain are increasingly recognizing and responding to this need today by adapting their business models to create more value and with the consumer-driven market challenges in mind.

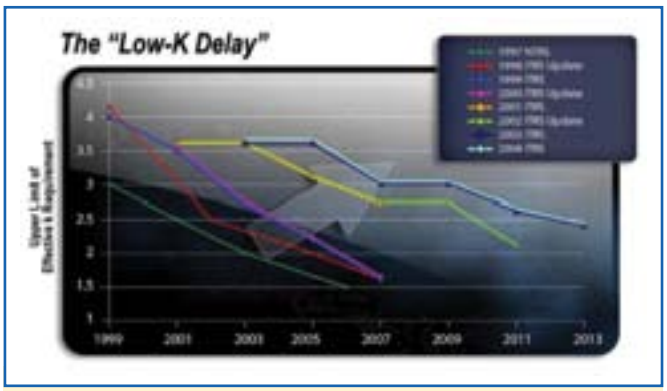

Figure 2. The 'Low-K Delay'.

Co-development - beyond roadmaps

One might view co-development as similar or the same as our 'Industry Roadmaps.' This process of setting and communicating key targeted industry technology advances with associated timelines for implementation certainly have played a vital role in our industry's past - and will continue to in the future. However Roadmaps are typically two-dimensional diagrams indicating a singular performance target or property versus a timeline typically given in years. These documents are by nature in simplified form and important considerations may be left off. Roadmaps describe what is needed by when, but say nothing about the 'how' nor give insight into the relative priority of conflicting roadmap requirements. They don't necessarily consider the tradeoffs inherent in device design and process development. Through collaboration and communication between key members up and down the supply chain a better 'roadmap' for success can be created to achieve the best product result in the shortest time with least risk and expense.

The Low-K Example

Low-K interlayer dielectric films are a good example of the limitations of Industry Roadmaps. The implications of using low-K dielectric films in the fabrication of advanced IC's span several layers of the supply chain - the front-end and back-end of the wafer fab, assembly & test operations, and even into board-level assembly. Within the wafer fab industry itself there were, and are, many companies - users and suppliers alike - that were highly focused and highly invested in solving 'their piece' of the low-K challenge. After some lack of success and delays in overall industry progress, some suppliers realized the limitations of working alone or with a limited set of partners - and began collaborating with partners across the wafer fab supply chain to deal with a complex set of integration issues. In total hundreds of millions if not billions of dollars and more than 10 years have been spent by the industry in pursuit of the semiconductor roadmap for low-K technology. Yet this has been insufficient to fully address the complexities of implementing low-K dielectrics - as we have seen by the number of revisions and delays in the ITRS Roadmap for Low-K Dielectrics *(Figure 2)*.

Even after significant integration challenges for device fabrication were resolved in the wafer fab - new issues followed in device assembly due to weakness of the low-K dielectric layers inside the device. In some cases the situations ultimately lead to redesign of the device structure and fabrication process itself to address the unexpected assembly issues, or the low-K technology itself was abandoned in favor of other approaches. It is quite possible that an earlier and stronger knowledge interchange among supply chain members regarding technology limitations, implementation issues and best trade-off options could have led to more practical low-K targets and implementation schedules. This could also have prevented expensive and time consuming redesign. Such information and planning options are even more critical to understand in today's consumer-driven market where time-to-market and short time to high yielding volume manufacturing is vital to success. While hindsight is '20-20', the low-K roadmap example demonstrates the need for an early process for understanding and selecting risk and cost trade-offs as well as understanding downstream supply chain issues.

Co-development value proposition

When one considers that the product-life-cycle and time-to-market are already short and getting shorter in the consumer electronics market, the case for co-design and co-development becomes even more apparent. Finding and involving expert partners early in the design and development processes offers many benefits *(Figure 3)*. With an early discussion of best options, potential problems and alternative approaches it is much more likely that a complete solution will be determined to realize the product concept. The solution may be determined in a shorter amount of time thereby accelerating time-to-market. Robust approaches can be identified thereby reducing the likelihood of encountering unnecessarily low-yielding or high-cost processes. Costs of R&D will be distributed and carried by collaborators with strong core-competencies in the critical fields. Re-engineering or redundant engineering in subsequent commercialization phases can be reduced by anticipating challenges and potential problems in device manufacturing and downstream assembly processes.

Choosing the right collaborators

Partnering in and of itself does not ensure success. Each situation has a unique set of business objectives and technical hurdles so selecting the right team is important. Don't rely on assumptions about either strengths or weaknesses of potential partners. Ideally partners are chosen for their breadth of vision and expertise in co-development. Its best to start working together early in the process so as to allow time to explore and define the real business and technical objectives as well as the options, constraints and trade-offs that may be necessary. It is best to consider within the scope the whole process instead of designing unit processes independently from each other. This will assist in achieving the best, highest yielding and lowest cost overall process. Above all it is vital that the selected partners each bring a unique "value-add" to the team. Traditionally materials companies have not played a strategic role nor have been seen as having a distinct 'value-add' to bring to the

Figure 3. The Value of Co-Development.

Figure 4. Spanning the supply chain can provide insights and synergies which lead to 'value-add' ideas.

design and development of semiconductors and electronics systems. For the most advanced materials companies this is changing.

As materials become more critical to semiconductor technology innovation, materials suppliers are playing an expanding role in co-design and development. Larger global companies with broad capabilities can help with process development; materials integration and technology fan out to global facilities or subcontractors. Progressive materials suppliers have newer business models that offer more value to their customers. More and more, the technology of materials - and even the technology of consumer electronic products for that matter - is not differentiating in and of itself. In consumer product markets it is often not the technical dimensions of what the supplier offers that make it distinctive or preferred - but rather the perceived benefits or 'value-add' to the consumer. Likewise for material suppliers - often it is increasingly the non-product dimension of their contribution that adds value to the customer. Leading materials companies are now more likely to have flexible business models that address the higher level business needs of customers in addition to the technical needs. They are more likely to be open to sharing in R&D costs, business risk or even applying non-technical core-capabilities to the customer's business needs.

Materials suppliers can add value in today's fast-evolving electronics industry through progressive business models that offer customers a range of relationships to fit their business needs - from purely transactional to strategic partnership. The kind of materials partner more likely to bring 'value-add' to a team of co-design and co-development partners should have characteristics such as: (a) strong core competencies in technology and manufacturing; (b) global infrastructure with strategically located local sites for sales, technical support, and manufacturing; (c) strong focus and expertise in the electronics industry - ideally with multiple touch points spanning the industry supply chain - integrated under one business operation globally with strong cross-region teams to serve multinational customers; (d) large and ongoing investment in R&D; and (e) have relationships throughout the industry with potential partner companies for fast formation of teams and integration of offerings.

For illustrative purposes *Figure 4* shows the breadth of electronic materials and capabilities, from basic silicon metal to final system assembly. With such a span of expertise it is possible to see and propose optimization possibilities for device and system assembly processes across layers of the electronics supply chain. In addition, some materials suppliers are companies that serve other industries in addition to semiconductor and electronics. In this latter case the technical and business capabilities built up for other industries can be brought to bear even on electronics industry customer's problems in order to offer innovative solutions that might not otherwise be common to the electronics industry.

Co-development examples

Several examples from simple to complex are discussed to illustrate a range of co-development ideas.

Customized product and application method

A SATS company operating in Asia faced 2004 demand several times higher than their 2003 production. They evaluated their process and determined they needed to switch from a 2-part chip coating system to a premixed system and also needed to change the way they applied the chip coating to a new method. They felt this would give them several advantages: (1) increase device yield; (2) simplify the production process; and (3) reduce waste. A new solution was developed which included manufacturing the pre-mixed product based on a customized mixing ratio, and packing and supplying the pre-mixed product in a customer specified container for the new application process. Through effective cross-area and cross-functional communications the customer and materials supplier partnered to radically reduce the lengthy process for new product development and provided speed of sampling for a custom made product. This solution aligned to the customer's objectives and delivered improved productivity and cost reduction.

LED lens solution

A manufacturer of light-emitting diodes (LEDs) required expertise in polymeric lens materials and associated injection molding processes for a completely new class of lens material. The new material set selection was driven by application requirements for a new emitter design that would operate at higher device temperatures, have higher flux densities and the device must also be compatible with lead-free surface mount assembly processing. The materials expertise and molding process

know-how resided within two different business units at the materials company - one serving the electronics industry (for the materials expertise) and one serving the molding fabrication industry (for the processing expertise). As a result of the flexible business model employed by the materials company the two separate business units easily and effectively united to develop a material and molding process solution that was critical to the success of the LED product. High volume SMT processing was a requirement of the LED manufacturer's customer and the existing lens material could not withstand the 260∞C Pb-free solder reflow temperatures. The materials supplier quickly identified a silicone elastomer formulation which would best meet the customer's specifications and then worked with mold fabricators on mold design, ran its own internal injection molding trials and successfully produced prototype lenses for the LED manufacturer. Support and know-how was then provided to validate the product and process at a molding subcontractor site. The cross-business team worked through several iterations of process and product optimization to improve the properties and processability of the materials. As a result the LED manufacturer has successfully launched its new product using the new material set and molding process.

Turning competitors to partners

A global supplier of specialty materials such as photo resist used in semiconductors and flat panel display applications happened to also compete with another materials company in several electronics segments. One of the photo resist supplier's business goals was to develop an advanced photo resist material. They had determined that a silicon-based resin would be key in developing their new resist formulation and their timeline was tight. They considered developing the new resin internally but also wanted to explore the option of using an external supplier. The resist supplier approached the other materials company about the possibility of co-development, although they were somewhat apprehensive since the companies compete in the interlayer dielectric market. After a meeting to understand the business and technical needs the prospective partners determined that a new silicon-based resin could meet the resist supplier's needs, help them save time and resources, and in addition alleviate patent concerns. As a result of the initial business discussions and rapidly supplied engineering evaluation samples the attitude toward each other as competitors changed significantly and the groundwork was laid for a collaborative agreement. From there the companies agreed on guiding principles for the collaboration as well as a shared business plan and R&D costs. Both companies were able to achieve their business objectives at lower cost, shorter times and lower risk.

Framework for collaboration

When it comes to collaboration, no two situations are the same. Collaboration work can be thought about as a continuum from simple to complex (*Figure 5*). A collaboration can be as simple as an informal exchange of market or technical information that benefits both parties. Further along the continuum is a more formal alliance, probably covered by a contract, where parties agree to pursue their mutual objectives together, and one or both are paid a pre-determined fee for the value they provide. A contract will likely also include provisions related to IP ownership, confidentiality, staffing and communications. At the other end of the continuum from informal exchange is a full-fledged joint venture, which is a complex legal agreement creating a separate business entity. In selecting what type of alliance to pursue, it's generally true that simpler is better - and definitely faster. But in any type of alliance, both partners must add unique value through a differentiated offering - otherwise, there is no reason to form an alliance.

Whether an alliance is formal, or informal - with other suppliers, or with customers, these are some of the guidelines that will help ensure success. Be sure you and your partner agree on these:

- Shared and documented objectives
- Clear roles and accountabilities
- Shared investment and upside potential
- Frequent go/no go milestones
- Open and constant communications
- Willingness to 'kill' a project if milestones are not met

Summary

Consumer electronic devices are driving a significant portion of today's industry growth. Consumer-driven electronic device markets are dynamic and difficult to predict and forecast. Yet time-to-market and fast ramps to high yielding production are key determinants of success in this market environment. IDMs and OEMs have turned to outsourcing to reduce development and manufacturing costs in order to focus resources on their core competencies to remain competitive. In addition, shorter time-to-market requires that technical obstacles and design trade-offs be identified early and quickly. Early involvement of value-add partners leading to co-development is an approach that has been used successfully to increase development results while reducing costs and risks. Progressive suppliers are recognizing and responding to this trend with new business models that create value and share risk with collaborators in their chosen markets. Leading materials suppliers are innovating not only new technology but also new approaches to collaboration. Several examples and insights have been provided to stimulate further thought and interest in co-development by involving suppliers at earlier phases of product and process design.

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Figure 5. Continuum of Collaborative Relationships.