The SEMI International Standards Program – History, Successes and Lessons Learned to Address Compound Semiconductor Manufacturing Challenges

Bettina Weiss

Director, International Standards, SEMI Global Headquarters,
3081 Zanker Road, San Jose, CA 95134, USA
Phone: (1) 408.943.6998; Email: bweiss@semi.org

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ABSTRACT

The history of SEMI and its International Standards Program are described as a forum and mechanism to develop critical global industry standards that are widely applicable. This presentation will explain past and current successes, challenges, milestones and lessons learned and provide suggestions for increasing the value and industry impact of compound semiconductor standards worldwide.

INTRODUCTION

SEMI was founded in 1970 as a trade show association, primarily to support the small but growing semiconductor equipment segment which needed formal representation. In the early 1970s, semiconductor device manufacturers were still vertically integrated and coped with the entire manufacturing process in house, from pulling silicon ingots, to wafer processing to packaging, final test and assembly, without outside suppliers or subcontractors. Over the next several years, SEMI's portfolio of products and services quickly grew to address areas such as advocacy, Standards, technical programs and conferences and market statistics. It is the area of SEMI Standards that is being described here more closely.

HISTORY

In the 1970s, silicon was already the established material of choice for integrated circuits, but consensus-based industry standards were virtually non-existent. Custom-made solutions for each individual customer were the norm.

The semiconductor industry, including the equipment sector, experienced significant growth in those days. The lack of standards or any coordinated industry-wide or segment-wide approach led to a serious shortage of silicon and significantly strained the entire supply chain which grew at a slightly slower pace over all. The need for standards became obvious. The variety of equipment, processes, and materials had eventually led to over 2,000 different user-created silicon wafer specifications, without any consolidation or search for common ground. To address this urgent need, a few SEMI member companies and others initiated a wafer standardization effort in order to eliminate the waste of having non-standard wafer sizes that nobody else could use.

This effort culminated in the first standards meeting on May 4, 1973 when George Moore and Trevor Law called upon industry experts from 13 companies to focus on standardizing wafer dimensions and other parameters. As a result of subsequent meetings, the first draft silicon wafer specification was developed that same year. Twelve months later, 80-85% of 2" and 3" wafers met the draft standard, and SEMI consequently became a standards development organization. The first draft silicon standard was absolutely critical for two reasons: 1 – by using the industry standard, the silicon shortage was first kept at bay, later eliminated and 2 –even more importantly, these early drafts provided the foundation for the equipment industry to become a stand-alone industry sector.

INTERNATIONALIZATION

The early successes in silicon set the stage for other areas to follow, such as chemicals/gases, facilities, safety/EHS, lithography, test, assembly and packaging and many more. Semiconductor standards

work carried out in the US also attracted the attention of organizations in other regions, such as JEIDA (Japan Electronics Industry Development Association) in Japan. For example, the Japanese developed silicon standards roughly at the same time as SEMI, but approach and results were quite different. Increased communication across regions, personal interaction of stakeholders and the need for cooperation brought Japan and the U.S. and gradually other regions closer together. DIN (Deutsches Institut fuer Normung) in Germany and ASTM (American Society for Testing and Materials) in the U.S. joined the effort, and to this day participates in joint, SEMI-hosted organization meetings on standardization.

The 1980s also witnessed the emergence of SECS/GEM standards (SEMI Equipment Communication Standard/Generic Equipment Model) which continue to be the basis for fab communication. Before the SEMI SECS standards were developed, there was a veritable Tower of Babel in the fabs. Tools from different suppliers couldn't talk to each other. Manufacturing Execution Systems were different, and there was no standardized computer-to-computer communication system between equipment and shop floor MES. SECS let all these different tools and MES communicate.

The internationalization of the activity and the increasingly sophisticated fab requirements led to a heightened awareness of standardization needs and the benefits consensus-based global standards provide to the industry. This trend continues today as cost for custom application in factory integration, automation and architecture have grown exponentially.

SEMI INTERNATIONAL STANDARDS PROGRAM TODAY

Today, over 1,300 industry experts are enrolled in the SEMI International Standards Program, lending their expertise to the successful development and deployment of global specifications and test methods that help reduce manufacturing cost, speed up time to market and provide an industry-wide understanding of best practice. 17 global technical committees with hundreds of task force as well as close links to the ITRS (International Technology Roadmap for Semiconductors) and other industry organizations ensure a continuous dialogue among stakeholders (Figure 1).

But more commitment and proactive thinking is needed in order to continuously develop standards as enablers of and solutions for technology trends. Involving device manufacturers and suppliers of equipment and materials early on to determine not only the technical requirements for a new standardization project but also discuss the economic feasibility associated with large industry trends remains a challenge. The value proposition of SEMI Standards – the benefits of developing and using them but also the opportunities for exchange that this neutral framework brings to the industry – need to be communicated to higher level executives just as much as to front line process engineers.

SUCCESSES AND LESSONS LEARNED

One example where timely and consensus-based standards development paid off was when a major device manufacturer opened its fab in Ireland in the early 1990's. A requirement for all tools purchased for this fab was compliance to SEMI S2-91, SEMI's flagship semiconductor manufacturing equipment safety guideline. By engaging suppliers early on, this particular device maker was able to significantly reduce fab ramp-up cost by providing uniform equipment safety specifications which the suppliers in turn could already build into the design stage of their equipment.

The transition to 300mm wafers provided further opportunity for standardization and produced solid long-term results, especially in the area of physical interfaces and carriers. A SEMI survey conducted in 2003 showed that 62% of the 85 respondents saw an increase in the use of SEMI Standards since 300mm specifications were published (Figure 2).

For 300mm software, however, the results were different and challenges have just recently been completely resolved. While standards areas such as metrics, EHS and silicon stabilized early on, software revisions, frequent reballoting and consequent "bug fixing" in the field resulted in an estimated $200 million price tag for the semiconductor industry collectively. The lack and delay of a collaborative approach among device manufacturers and suppliers has been openly acknowledged by representatives of the device community, who vowed not to repeat this mistake in the future. Now that 300 mm "prime" (second generation/mature 300mm) issues, particularly in the area of automated material

handling systems are being investigated and addressed, the device community has recognized the importance of developing standards and together with the supplier, to collaboratively develop industry guidelines for feedback and buy-in and to constructively look for ways to reduce cost. With R&D funding dwindling in our industry, standards will continue to be critical enablers for survival.

Emerging Technologies, such as MEMS (micro-electromechanical systems) provide fertile ground for standards as applications and products migrate from R&D to beta lines to commercialization. Last year, a *Preliminary Standard* was developed within only eight months that provides guidelines for generic fluidic I/O design and fabrication that can reduce redundant engineering effort and lead to improved design, manufacturability, testing and operation. With strong backing from his management and his own personal commitment, the task force leader was able to bring together interested companies, achieve consensus on the concept, develop a well-defined timeline and milestones and achieve the fastest publication of a document in years.

OPPORTUNITIES FOR THE COMPOUND SEMICONDUCTOR INDUSTRY

The compound semiconductor segment can benefit from the successes and lessons learned, and work is already underway in various task forces of the Global Compound Semiconductor Committee. Identifying areas of high cost and time investment often point to processes where a standardized approach can help reduce the pain of low repeatability and high failure rate. The second aspect is the economic analysis about the potential impact and benefit a standard could provide, alongside the technical requirements that were identified. Thirdly, utilizing existing resources such as the ITRS, customer guidelines and a close watch on technology trends typically contribute to mitigating risk and improving productivity. Last, but certainly not least, is the benefit of having a global forum where stakeholders can come together, establish a sense of community and agree on common ground rules (standards) while maintaining the possibility of distinguishing their products through special features/enhancements. The key to success lies in early stakeholder involvement and the realization that more often than not this is a collective effort among competitors and their customers, for the greater – and quite tangible – benefit of cost reduction and fast time-to-market.

CONCLUSION

For over 30 years, SEMI Standards have played a vital part in improving materials, equipment performance, processes and many other aspects of semiconductor manufacturing, resulting in significant cost savings and time-to-market improvements for the industry and individual companies. Standards play a particularly important role in any technology transition and provide an opportunity for the compound semiconductor industry to review current challenges and apply standardization approaches where appropriate and needed. The SEMI International Standards Program will provide the necessary infrastructure for successful Standards development, enhanced industry stakeholder interaction and industry growth.

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ACRONYMS

JEIDA: Japan Electronics Industry Development Association; now JEITA Japan Electronics Industry Technology Association
DIN: Deutsches Institut fuer Normung (German Institute for Standardization)
ASTM: American Society for Testing and Materials; now ASTM International
SECS/GEM SEMI Equipment Communication Standard/Generic Equipment Model
ITRS: International Technology Roadmap for Semiconductors

Figure 1 – Committee Membership in the SEMI International Standards Program January 2006

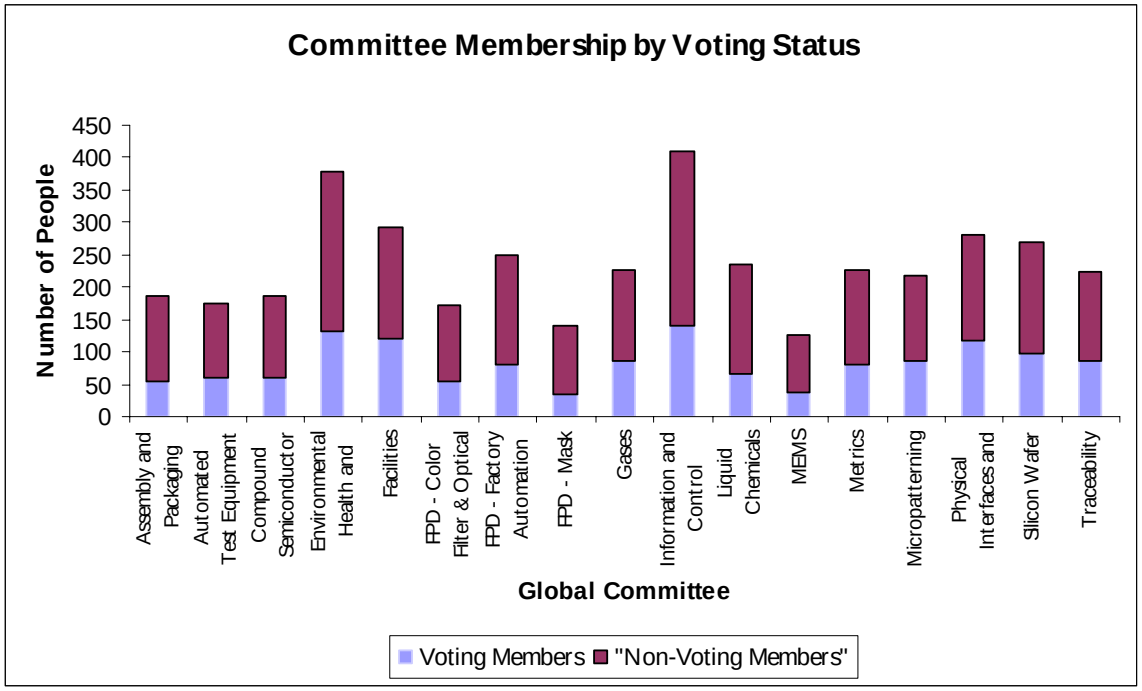

Figure 2 - Excerpt of SEMI 300mm Standards Usage Survey 2004