Business 4.0-driven Spare Parts Management in the Semiconductor Equipment Industry

Abstract

In the capital intensive semiconductor industry, spares parts management is a complex, integrated logistics system that demands intelligent management. The inability to make the right quantity of spare parts available at the right time can lead to either customer dissatisfaction or high inventory write-offs. Business 4.0™ levers, namely automation, cloud, intelligent, and agile, play a critical role in building a fully optimized, intelligent, and agile supply chain that is integrated across installed bases. Such a supply chain will not only enable organizations to plan in real-time and provide superior customer service, but also reduce spare parts inventory and operating costs.

This paper discusses how semiconductor equipment manufacturers should approach spare parts management to create a new 'service oriented' business model, in addition to strengthening their traditional product sales.

Embracing Business 4.0: 'Servitization' as a New Value Driver

Whether a maintenance and repair organization (MRO) is internal to a firm or provides maintenance services to an external customer, efficient spare parts management is critical. Any organization that has ever experienced sudden component failure during critical manufacturing stages can vouch that it is a formidable situation. At the same time, piling up spare parts in inventory to mitigate risks associated with unexpected machine failure leads to increased chances of obsolescence and ultimately high inventory write-offs, besides increasing operational costs. Organizations must, therefore, have optimal inventory of spare parts to avoid both the scenarios. However, the process of identifying optimal inventory is tedious and time consuming, ties up labor and management resources, and requires information that may not be easily available in a traditional manufacturing setup.

An Industry 4.0 model driven by Business 4.0 principles is changing this equation. Disruptive technologies such as the internet of things (IoT), cloud, and analytics are transforming businesses across industries. Each of these technologies, either individually or in unison, is enabling organizations to consider the 'servitization' model for new revenue sources. Servitization is a transformative journey that enables manufacturing organizations to develop and offer services and solutions, in addition to their traditional product offerings. This new model creates various channels for delivery of the precise solution that customers need and, that too, at a fraction of the upfront investment typically required. It can also free customers from the need to constantly maintain and service the products they buy, automating the process of maintenance and service requests to a great extent.

Spares Management Critical, but Challenges Abound

The global sales of new semiconductor manufacturing equipment jumped 14% from USD 56.62 billion in 2017 to an all-time high of USD 64.5 billion in 2018. Aggressive spending on semiconductor fabrication equipment will continue beyond 2022, as more semiconductor fabrication plants emerge, requiring about USD 220 billion worth of new equipment. While the installed base for global semiconductor manufacturers is growing rapidly, their customers are looking for ways to

minimize downtime, improve device performance and yield, and optimize factory output and operating costs. This is creating immense opportunities for fabrication equipment manufacturers to leverage the 'servitization' model and realize additional revenues from their maintenance and services functions. For leading semiconductor equipment manufacturers, services revenue is typically around 25% of the total revenue[1] and is growing in tandem with the expansion of the install base of the equipment. This increased focus toward selling spare parts and offering after-sales services is apparent from the growing professional services related revenues for leading semiconductor equipment manufacturers in recent years.

Success of the new service-oriented business model, however, depends heavily on effective spare parts management. This is because, on the one hand, fabrication equipment manufacturers need to abide by stringent service levels and contractual agreements set by their clients. On the other, they need to minimize inventory-related costs that strain their budgets.

While equipment and maintenance-related expenses in semiconductor factories, especially wafer fabrication units, typically run into billions of dollars, the lion's share of the investment (typically 60% to 70%) goes into operating these factories.

At the same time, technology demands in the semiconductor industry are getting more challenging by the day with manufacturing accuracy moving into the sub 0.1 micron levels. This not only puts pressure on the equipment manufacturers to come up with new products but also forces them to better manage service and spare parts for the machineries sold. To fabricate an integrated circuit or chip, a wafer moves hundreds of steps from one piece of equipment to another. A simple glitch in the equipment or a process step can cause defects that can result in scraps and/or poor yield, escalating costs and further adding to the complexity. Improper installation or malfunctioning components can also upset the entire production ecosystem. For instance, a wrong O-ring installation in a portion of a sub-fabrication equipment or a malfunctioning pressure regulation system can cause contamination, negatively impacting fabrication.

Circumventing the Challenges for Servitization Success

Managing spares operation in semiconductor equipment organizations requires effective global logistics systems and collaborative partnership with customers, underpinned by the right support functions. It requires seamless collaboration between the internal departments of the equipment vendor as well as the application of digital technologies to improve predictions and minimize disruptions. All these components of the supply chain must work in tandem.

Business 4.0 driven spares operations help all the components in the supply chain work in tandem. Its enablers include:

Connected devices to monitor equipment and detect malfunction

Managing replacement parts for field service is different from standard inventory planning on the production side of a product's lifecycle. Aftersales supply chains are more complicated and tougher to manage. IoT improves equipment uptime through remote diagnostics, troubleshooting, and predictive maintenance. IoT sensors connected to fabrication equipment enable real-time monitoring of equipment performance (see Figure 1).

An extensive system that captures data from each IoT sensor can conduct a performance degradation assessment in real-time and generate a health radar for easy visualization. The health map and risk radar chart help identify potential issues

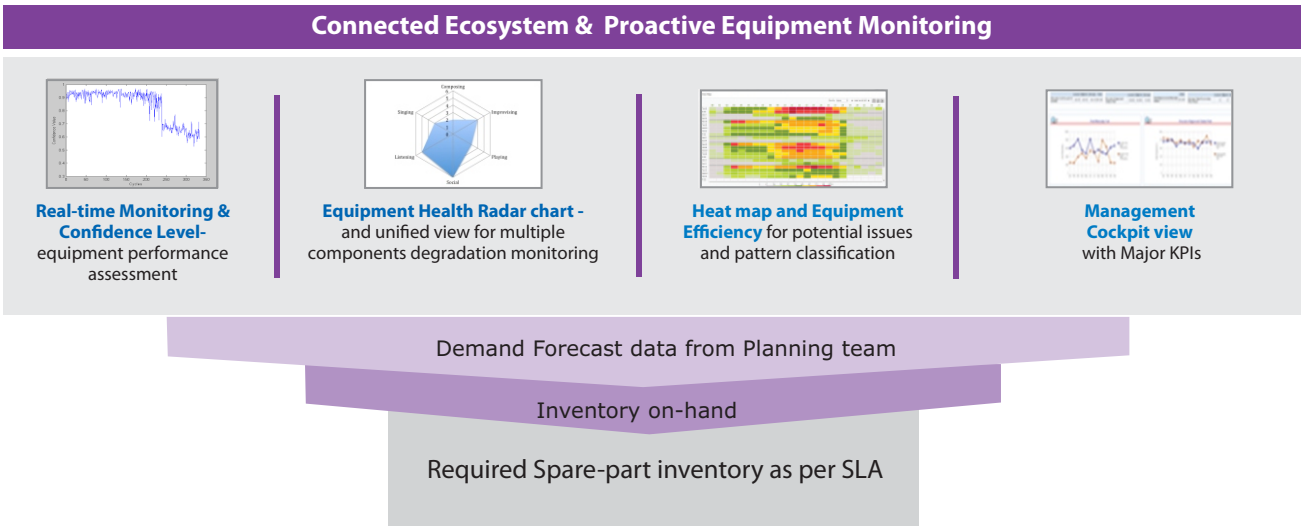

Figure 1: Connected ecosystem and proactive equipment monitoring

through pattern classification to prioritize maintenance decisions. Further, the program can be tailored to predict spare parts demand, leveraging the real-time equipment health-related data, the demand forecast generated by spares planning team, and inventory on-hand.

Accurate demand forecasting and inventory assessment

Companies realize that the cost of fabrication disruptions, if spares aren't available when needed or if they are of inconsistent quality, can significantly outweigh the perceived benefits of low-cost alternative parts. This makes demand forecasting through demand segmentation and advanced statistical analysis a critical must-do. Equipment vendors are, therefore, leveraging big data generated by IoT sensors and machine learning techniques to develop demand forecasts. This means superior supply assurance with more efficient use of spare parts inventory, translating into savings for customers.

Another critical aspect is inventory optimization that balances the needs of equipment makers and customer obligations (see Figure 2). For semiconductor equipment manufacturers, inventory turns are typically low, in the range of one to five. Equipment makers also need to fulfill volume commitments to their customers where they need to supply products under varied demand conditions. This necessitates a cyber-physical inventory management solution that can take into account machine components' performance in real time while calculating the desired spare part inventory level.

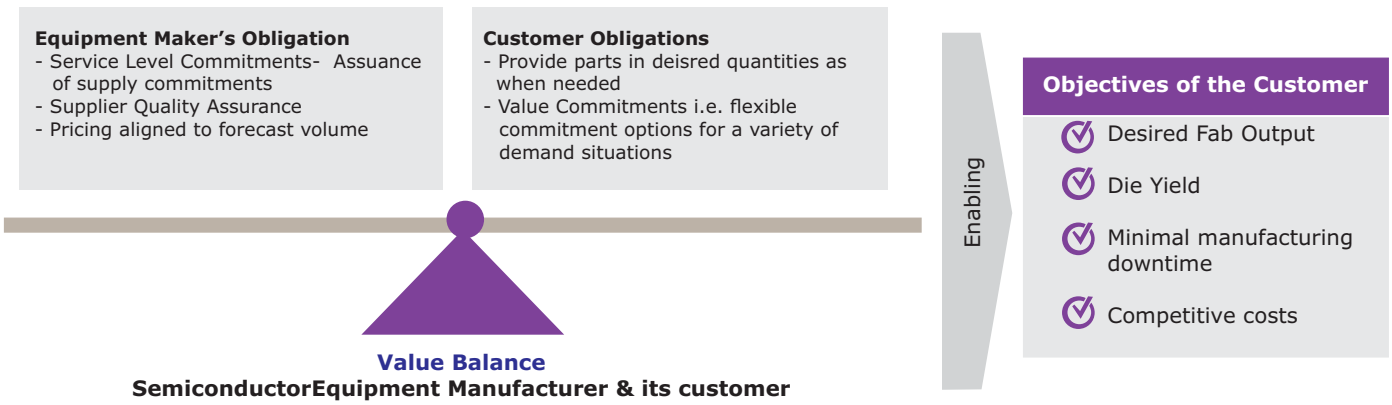

Figure2: Balancing obligations between an equipment manufacturer and its customer

Digital collaboration across the fabrication value chain

This boils down to implementing a cloud-enabled workplace that supports collaboration across design, installation, performance, and replacement of spare parts. Collaboration here refers to not just between the equipment manufacturer and customer, but also with the suppliers and sometimes a tripartite connect. For example, to ensure that the right parts are supplied at the right time, equipment vendors and customers can closely collaborate on the changing demand landscape via a platform, allowing for immediate visibility which can be acted upon to improve service levels.

Additionally, digital collaboration can help equipment vendors monitor the performance of their devices. Such collaborative efforts result in higher manufacturing yields and eventually lower costs.

Transitioning to 'Smart Fab'

As semiconductor equipment manufacturers increasingly recognize the importance of balancing spare parts availability with working capital and operational costs, technology will inevitably play a vital role in delivering the desired results. That said, simply implementing digital technologies will not solve the challenges of organizations with distributed and complex supply chains. Such organizations must thoroughly analyze their supply chains, recognize the challenges related to spare parts management, as well as understand the gaps in spare part management practices and policies. They must also take stock of the skillsets available and new ones required to overhaul the organizational structure in keeping with Business 4.0 principles. As with any new project, it is recommended that organizations start small with a pilot project when implementing an intelligent spare parts management solution and gradually expand the scope to optimize success.

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