FROST & SULLIVAN

2015

OPTIMAL+

2015 Global Semiconductor Test Visionary Innovation Leadership Award

FROST & SULLIVAN

50 Years of Growth, Innovation & Leadership

Contents

Background and Company Performance

Industry Challenges

Semiconductor companies are striving to increase their business performance and position themselves better to compete in their given space. However, these companies are dealing with extremely large volumes and a complex supply chain. As a result of the fabless semiconductor revolution, many semiconductor companies have highly distributed manufacturing operations geographically and use a number of contractors and sub-contractors. Frost & Sullivan points out that the diversity of their operations makes it extremely difficult for both Integrated Device Manufacturers (IDM) and fabless semiconductor vendors to get a clear picture of their business operations. As such, Frost & Sullivan notes that they need solutions that address these challenges to improve their operational efficiency, top-line performance, and profitability.

In addition, the emphasis on quality by the customers of semiconductor vendors has expanded beyond the traditional verticals concerned with quality - such as automotive and medical device manufacturers. There is now significant emphasis across industries on product quality, as devices become more complex, the supply chain of various products become increasingly disjointed, and end-user expectations on the quality of their devices increase. To reduce the costs incurred by semiconductor vendors, reducing Return Merchandise Authorizations (RMAs) has become a priority. However, achieving this goal is no simple task, due to the wide range of factors that cause devices to fail.

To address these challenges, semiconductor companies report to Frost & Sullivan that they are collecting data from more operations, storing data for longer periods of time, and performing test earlier in the product lifecycle, resulting in exponential growth of the data they are collecting. However, they are extremely challenged in extracting useful information from that data and need more innovative Big Data solutions.

Focus on the Future and Best Practices Implementation

Focus on Unmet Needs

Optimal+ enables its semiconductor customers to find opportunities in their supply chain to improve their production yield, productivity, and product quality. The concept of Optimal+ emerged with Dan Glotter, its founder, who, while managing the fabrication plants of a leading global semiconductor vendor, realized that there was a huge opportunity for semiconductor companies to recover yield by saving the good chips produced mistakenly labeled as bad. By providing these companies with information quickly, a significant amount of money could be saved. However, providing the needed information in a timely manner so that customers can make decisions and take action swiftly is quite difficult, as the semiconductor manufacturing environment involves large volumes of data and numerous participants in the supply chain.

Looking at parametric, geographical, equipment and other types of data, Optimal+

solutions provide semiconductor vendors with solid information about their operations in minutes. This is a tremendous improvement compared to the hours or days it takes to receive the equivalent data with most of the tools they currently use, which were developed internally due to the absence of commercial solutions in the market. The solutions identify issues based on statistical anomalies, such as a drop in yield at a test site or a tester issuing the same failed results for hundreds of devices in a row. Both the semiconductor vendor and its suppliers are then alerted so that corrective action can be promptly taken. For example, production yield varies slightly over time. Optimal+ helps customers minimize dips in yield, enabling them to maintain a high level of yield entitlement. Optimal+ solutions also enable customers to manage their resources intelligently by identifying areas where more or less testing is needed.

Global Ops is the core offering from Optimal+ to which the other solutions can be added. It focuses on production yield and productivity. Other solutions include Escape Prevention, Outlier Detection, Test Floor Ops, and Test Time Reduction (TTR). Escape Prevention, which performs deterministic analysis of test escapes, and Outlier Detection, which performs statistical analysis of test escapes, help customers improve their product quality. These solutions have experienced increasing interest from customers, due to the greater emphasis on product quality by customers of semiconductor vendors across industries. Test Floor Ops provides customers with real-time access and deep visibility into their manufacturing floor, enabling them to look at virtually every connected tester and visualize a range of metrics on each tester. It has been of particular interest to IDMs, but is also seeing increasing demand from fabless semiconductor companies that have consigned testers to their subcontractors and want to make sure they are fully utilized. Rounding up the offerings from Optimal+ is its TTR solution, which focuses on reducing test times using both classical and adaptive TTR techniques.

Visionary Scenarios through Mega Trends

Frost & Sullivan firmly believes that Optimal+ is the epitome of visionary innovation as it relates to Big Data analytics for the semiconductor industry. The company's solutions unlock the potential from Big Data for IDMs and fabless semiconductor vendors. Typically, Big Data involves 3 key aspects including extremely large volumes of data, high data speed, and wide data variety. With its roots in high volume manufacturing for semiconductors, Optimal+ solutions efficiently handle the challenge of a large volume of data and high data velocity. Some of Optimal+ customers already have over 30 terabytes of data in their database. The company also adds the notion of value to the mix. While many companies are looking for Big Data solutions without a plan in place to extract value from that data, Big Data is more than a buzzword for Optimal+.

The company demonstrates value by providing solutions that collect and clean high-volumes of data emanating from OSATs and foundries across the global supply chain; automate its analysis through flexible rules creation; and deliver real-time actionable insights to semiconductor teams that result in quantified benefits to its manufacturing operations and end customers.

Optimal+ solutions deliver measurable results to customers, including yield recovery increases of up to 2%, TTRs of up to 30% over traditional methods, improvements in operational efficiency of up to 20%, and up to 50% reduction in test escapes. Frost & Sullivan appreciates the fact that Optimal+ solutions provide complete control and visibility of the data streams to the IDM or fabless semiconductor vendor as opposed to relying on data provided by the subcontractors, resulting in strong value and ROI.

Growth Pipeline

Optimal+ delivers a high return on investment (ROI) to its customers, which augurs well for its future growth. One of the primary benefits for customers is the ability to improve product yield, without requiring any changes to manufacturing operations. Optimal+ improves production yields for its customers by up to 2% solely based on test. In addition, the solution can reduce test time by up to 30% over traditional TTR methods using adaptive TTR capabilities, thereby increasing customer productivity. As a result of the visibility customers gain into their supply chain by using Optimal+, various opportunities can be identified to improve their operational efficiency. For example, fabless semiconductor vendors may realize that they do not require as many consigned testers, while an IDM may realize that they do not need to purchase as many testers as previously thought, resulting in significant capital expenditure (CAPEX) savings. Optimal+ customers have been able to increase their operational efficiency by up to 20% by optimizing their operations. This has been enabled by the visibility the solution provides them into their diverse supply chain.

In addition to improving yield, Optimal+ also helps its customers improve on quality. The solution provides a reduction in test escapes of up to 50%, reducing the number of RMAs. Semiconductor vendors are performing more RMA analysis, as the emphasis on quality has grown in their customer base. With Optimal+, they can correlate data to information in their RMA database and implement changes to their testing activities, which would help to reduce RMAs over time. Frost & Sullivan points out that another significant challenge with RMAs is the diverse reasons for device failures. Optimal+ can be extremely helpful to product engineering from that standpoint with data queries. In addition, it enables customers to screen out for known RMA failures in the future, as once the root cause of a failure has been identified, customers can create a rule to catch such devices during manufacturing test.

Having proved itself in the high volume manufacturing environment, Optimal+ was approached by customers to help them in other areas of their business - notably New Product Introduction (NPI) and characterization. Introduced in June 2015, EXACT is a solution by Optimal+ that brings next-generation Big Data analytics to both high-volume manufacturing (HVM) and device characterization in the early stages of NPI. For HVM, EXACT provide new levels of analytic performance and capacity that will enable customers to explore and correlate manufacturing information across all phases of test operations to identify trends and opportunities that were not possible with traditional relational databases. For characterization, the nature of the work demands a heterogeneous set of

data. Optimal+ helps customers sort out this data more efficiently as compared to the previous manual-heavy methods. The solution also helps minimize wasteful characterization tests by identifying issues and stopping the test if need be. Test time can also be improved by identifying unnecessary tests and removing them prior to their release to HVM.

Blue Ocean Strategy

The most significant competitive advantage of Optimal+ is the footprint of its data network in Outsourced Semiconductor Assembly and Test (OSAT) companies and foundries. The company's global network spans 90% of OSATs and foundries, including major ones such as Amkor and KYEC. Made possible by partnering with key large semiconductor vendors, this impressive footprint makes it highly likely that the supply chain of any semiconductor vendor is supported by Optimal+. While customers are attracted to the concept of Optimal+, they are often skeptical about the ability of any supplier to cover their diverse supply chain. Having worked on developing its network over the past 10 years, Optimal+ has managed to put itself in a unique position in the market that is difficult to replicate. As a result, the company's solution is used by 6 of the top 10 fabless semiconductor companies in the world and by major IDMs. Customers include AMD, Broadcom, Freescale Semiconductor, Qualcomm, and ST Microelectronics, among others. In addition, these companies use Optimal+ to manage all of their manufacturing operations, as opposed to just one part of their business.

Process Design

Optimal+ is focused on serving the needs of the challenging semiconductor space and currently processes more than 20 billion chips on an annual basis, which represents a sizeable amount of the global chip production (approximately 10%). Over the past 10 years, the company has put in place a global data network that spans 90% of OSATs and foundries and is the backbone of its solutions. By creating rules, customers effectively mine the data coming from their manufacturing operations. Providing accurate and complete data sets to customers, Optimal+ enables IDMs and fabless semiconductor vendors to make informed decisions about their business operations.

Operational Efficiency

Optimal+ has operations across the globe including California, Texas, Northeast United States, Germany and Italy in Europe, and China, Taiwan, Malaysia, Singapore, Korea and Japan in Asia, with headquarters in Israel. The company employs experts in databases as well as highly skilled information technology (IT) personnel to ensure the smooth transfer of terabytes of data across the world, as customers may have subcontractors in the Far East and headquarters in North America or Europe. Deployment time of the solution varies according to the size of the customer and depends on the number of testers and participants in their supply chain. It ranges from a couple of months to 6 months.

Optimal+ also has a professional service organization that helps customers maximize the utilization of their solutions to address the business metrics they want to improve on. As an enterprise solution, Optimal+ does not restrict usage to a specific number of users in customers' organizations. As a result, while the targeted audience has been manufacturing management personnel, the solution is also being used by other departments such as product planning and finance, which is also a testament to the quality of the data generated by Optimal+ solutions.

Technological Sophistication

Optimal+ solutions rely on a global data network that has been developed over the past 10 years. Data is collected directly from every tester in the customer's internal or external supply chain and also includes MES (Manufacturing Execution Systems) data. The data is verified, aggregated and then securely transmitted directly to the semiconductor vendor for immediate analysis. The data is used by any one of the Optimal+ solutions, which are rule-driven analytic applications. Many different types of rules can be created; however, the most important ones are those that have the potential to impact yield, productivity and quality. All Optimal+ solutions come with a large number of built-in rules that have been proven in production. The company also works with each customer to adapt these rules to their organization, so the customer can start experiencing the benefits of the solutions as soon as the solution is implemented. Optimal+ solutions are also user-customizable. Using the Sequoia scripting language, customers can make very specific refinements by creating Virtual-Operations-Rules (VORs) that apply to their specific manufacturing operation needs.

Conclusion

Founded in 2005, Optimal+ provides powerful Big Data analytics solutions to semiconductor companies that transform their test data into actionable information to improve their yield, productivity, and product quality. It provides IDMs and fabless semiconductor vendors with unmatched visibility into their complex supply chain in real time, enabling them to take timely corrective actions when necessary and perform at their level best.

With its strong overall performance, Optimal+ has earned the 2015 Frost & Sullivan Global Visionary Innovation Leadership Award.

Significance of Visionary Innovation Leadership

A visionary innovation leadership position enables a market participant to deliver highly competitive products and solutions that transform the way individuals and businesses perform their daily activities. Such products and solutions set new, long-lasting trends in how technologies are deployed and consumed by businesses and end users. Most importantly, they deliver unique and differentiated benefits that can greatly improve business performance as well as individuals' work and personal lives. These improvements are measured by customer demand, brand strength, and competitive positioning.

Understanding Visionary Innovation Leadership

Visionary Innovation is the ability to innovate today in the light of perceived changes and opportunities that will arise from Mega Trends in the future. It is the ability to scout and detect unmet (and as yet undefined) needs and proactively address them with disruptive solutions that cater to new and unique customers, lifestyles, technologies, and markets.

Key Benchmarking Criteria

For the Global Visionary Innovation Leadership Award, Frost & Sullivan's analysts independently evaluated two key factors — Focus on the Future and Best Practices Implementation — according to the criteria identified below.

Focus on the Future

Criterion 1: Focus on Unmet Needs
Criterion 2: Visionary Scenarios through Mega Trends
Criterion 3: Growth Pipeline
Criterion 4: Blue Ocean Strategy
Criterion 5: Growth Performance

Best Practices Implementation

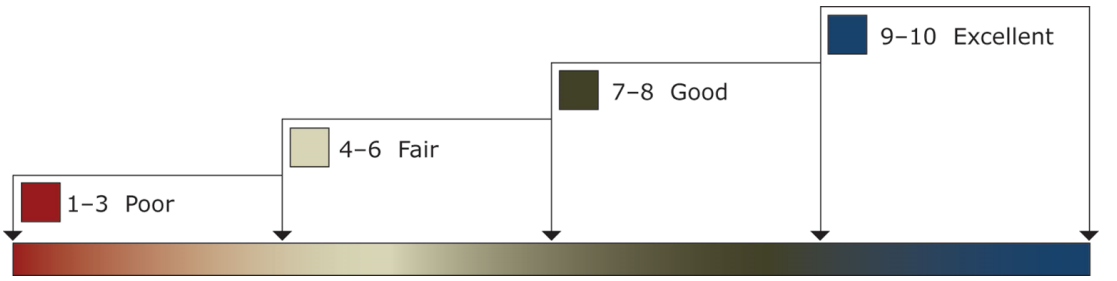
Criterion 1: Vision Alignment
Criterion 2: Process Design
Criterion 3: Operational Efficiency
Criterion 4: Technological Sophistication
Criterion 5: Company Culture

Best Practice Award Analysis for Optimal+

Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows our research and consulting teams to objectively analyze performance, according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation; ratings guidelines are illustrated below.

RATINGS GUIDELINES



The Decision Support Scorecard is organized by Focus on the Future and Best Practices Implementation (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criteria are provided beneath the scorecard). The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.

The results of this analysis are shown below. To remain unbiased and to protect the interests of all organizations reviewed, we have chosen to refer to the other key players as Competitor 2 and Competitor 3.

DECISION SUPPORT SCORECARD FOR VISIONARY INNOVATION LEADERSHIP AWARD

Measurement of 1–10 (1 = poor; 10 = excellent)			
Visionary Innovation Leadership	Focus on the Future	Best Practices Implementation	**Average Rating**
Optimal+	**9.2**	**9.4**	**9.3**
In-house Solutions	6.0	6.6	6.3
Commercial Solutions	6.8	7.4	7.1

Focus on the Future

Criterion 1: Focus on Unmet Needs

Requirement: Implementing a robust process to continuously unearth customers' unmet or under-served needs, and creating the products or solutions to address them effectively

Criterion 2: Visionary Scenarios through Mega Trends

Requirement: Incorporating long-range, macro-level scenarios into the innovation strategy, thereby enabling "first to market" growth opportunities solutions

Criterion 4: Growth Pipeline

Requirement: Best-in-class process to continuously identify and prioritize future growth opportunities leveraging both internal and external sources

Criterion 3: Blue Ocean Strategy

Requirement: Strategic focus in creating a leadership position in a potentially "uncontested" market space, manifested by stiff barriers to entry for competitors

Criterion 5: Growth Performance

Requirement: Growth success linked tangibly to new growth opportunities identified though visionary innovation

Best Practices Implementation

Criterion 1: Vision Alignment

Requirement: The executive team is aligned on the organization's mission, vision, strategy and execution

Criterion 2: Process Design

Requirement: Processes support the efficient and consistent implementation of tactics designed to implement the strategy

Criterion 3: Operational Efficiency

Requirement: Staff performs assigned tactics seamlessly, quickly, and to a high quality standard

Criterion 4: Technological Sophistication

Requirements: Systems enable companywide transparency, communication, and efficiency

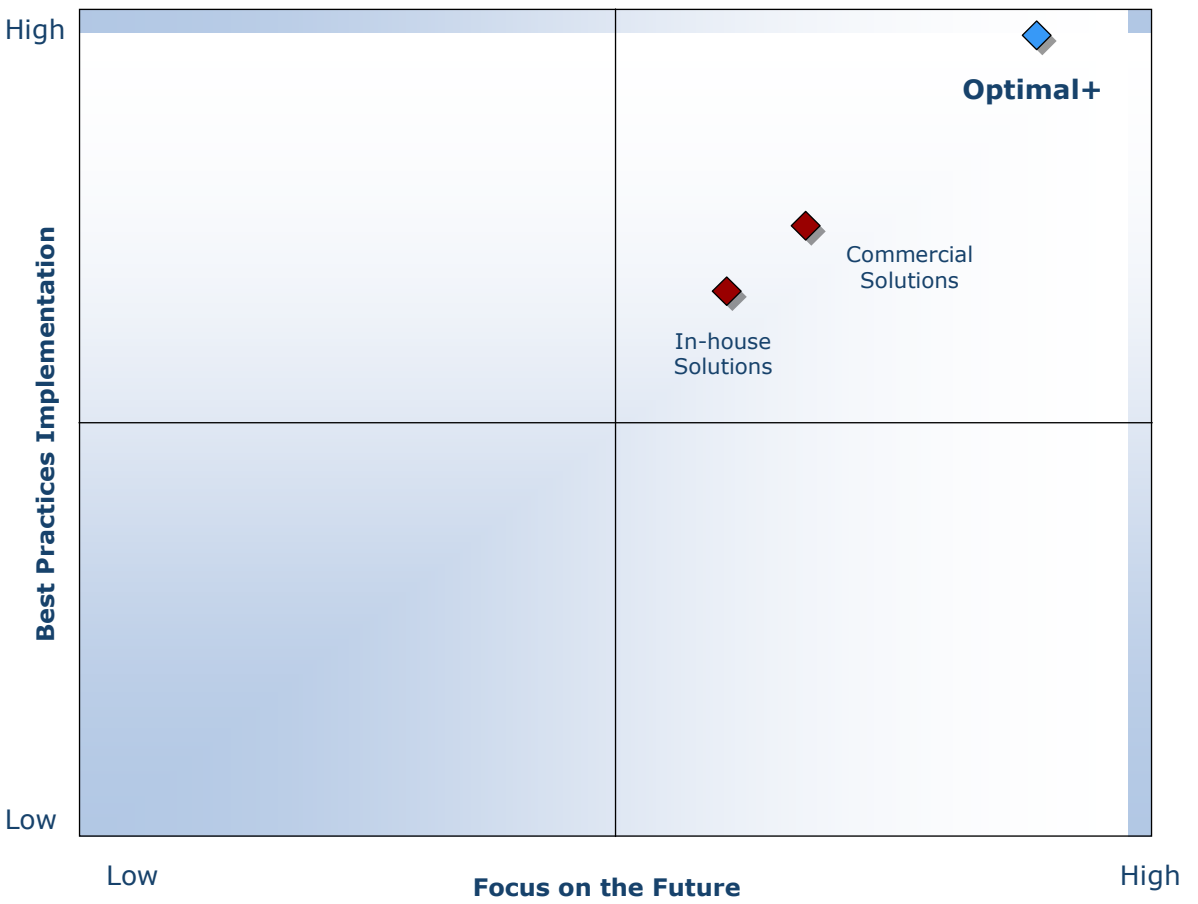
Criterion 5: Company Culture

Requirement: The executive team sets the standard for commitment to customers, quality, and staff, which translates directly into front-line performance excellence

Decision Support Matrix

Once all companies have been evaluated according to the Decision Support Scorecard, analysts can then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.

DECISION SUPPORT MATRIX FOR VISIONARY INNOVATION LEADERSHIP AWARD



About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best in class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages almost 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from 31 offices on six continents. To join our Growth Partnership, please visit http://www.frost.com.