Zero Defects

Entegris Newsletter

December 2018

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Advanced Materials Science: The Future of Innovation in the Fourth Industrial Revolution

We're in the Fourth Industrial Revolution, a period of massive transformation for our world. Artificial intelligence (AI), virtual reality, augmented reality, internet of things (IoT) devices, and the development of self-driving cars – to name a few – are fueling a data revolution. In fact, 90% of the world's data was created in the last two years. This data explosion is driving the need for not only more chips but the development of more sophisticated chips, which presents tremendous opportunities for the semiconductor industry.

This digital transformation demands a faster and more reliable computing infrastructure that will be enabled by new device architectures (i.e. 3D NAND memory devices), new engineered materials, and a greater level of material purity to manage and utilize the information-rich data created in all applications. While meeting these requirements is no easy feat, **Entegris is uniquely positioned to help the semiconductor industry meet the precision, purity, integrity, and safety challenges presented by the need for new engineered materials.**

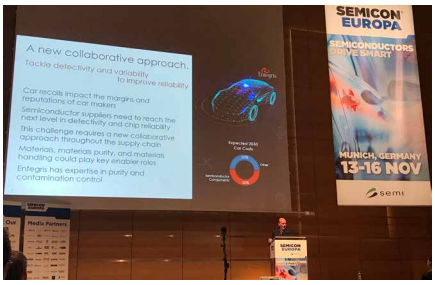
Specifically, the new materials, more sophisticated integration flows, and increased purity requirements needed to achieve higher-performance devices add fabrication steps and increase process complexity. While many industries have to do more with less, the semiconductor industry must do more with more — at least when it comes to complex manufacturing processes. Every new step added to the manufacturing processes creates a potential point of failure (or more) and solving each of these challenges can be time-consuming and costly. **With process steps growing to more than 100, even a yield loss of 0.01% can result in significant economic impact.**

› To know more, watch the video published in the Reuters Global Thought Leadership piece

A New Collaborative Approach to Automobile Industry Reliability Challenges

Entegris presented at the Strategic Materials Conference at SEMICON Europa on a new collaborative approach to automobile industry reliability challenges:

- Is this approach the solution to overcome challenges such as defects and contamination?
- What does Entegris propose?
- How could this support fab managers in their daily challenges and mid-term future objectives?



Speaker: Antoine Amade, Regional Senior Director EMEA at Entegris

› Read the full interview on the SEMI blog

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F +49 (0)351 795 97-498

Israel
T +972 (0)73 221 0000
F +972 (0)73 221 0030

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Examining the Small, Medium, and Large of Automotive Latent Defects

By Entegris Inc.

Today, modern vehicles run on over 100 thousand lines of digital code1, a number predicted to rise six-fold by 2025, and within just ten to twelve years electric and autonomous **vehicles are projected to have about half their value in onboard electronics**. These are sobering facts when you consider that over thirty percent of today's field failures are attributable to a vehicle's electronics.

Automotive recalls are not only damaging to a company's reputation but costly to the bottom line, making the impact of a corresponding rise in electronic-related recalls unsustainable. **One issue that is a known risk to automotive electronics is latent defects**; failures that do not show up in testing at the semiconductor fab or in subsequent burn-in testing of a component package. T**hese defects can develop over time, leading to failures that can result in safety hazards and expensive recalls.**

TOWARDS THE PPB LEVEL

Electronic defects are already a costly problem, but a number of factors could make them a much more significant problem in the future. The value of electronic components in vehicles is rising and largely attributable to digital control and comfort systems, advanced driver assistance systems (ADAS), and the continued development of fully autonomous vehicles. As vehicle cost increases, so does the expectation of "excellence" among buyers, as drivers and passengers become more reliant on embedded systems to guide and control their travels. **With electronics increasingly incorporated into safety systems and with the advent of self-driving vehicles, electronic system failures can be potentially life-threatening. This will intensify demand for recalls when problems arise. And as the usage patterns of vehicles increases, there will be more time for costly latent defects to develop.**

According to Electroiq*, a typical vehicle today contains between 5000 and 8000 microchips (chips). A manufacturer producing 25,000 vehicles per day with a parts-per-million (PPM) chip failure rate may produce 125 vehicles per day with lurking chip quality issues. If nothing changes, that number will multiply as more electronics are added to vehicles.

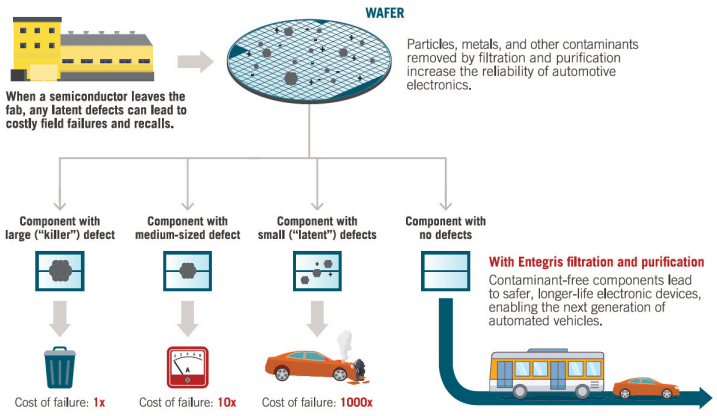
In order to overcome these challenges, chipmakers will need to find ways to either economically identify or prevent the creation of less reliable chips and remove them from the supply chain before they are installed in electronics packages that are, in turn installed into vehicles.

The cost of a failed chip at the semiconductor fab is relatively small (1X). If that chip passes through the packaging process and is identified in the process of burn-in, the cost of a failure has risen to 10X the fab prevention cost. And if that faulty chip makes it into the field and is installed in a vehicle before the problem surfaces, the cost can increase to an astronomical 1000X the cost of eliminating or preventing the problem at the fab, not taking into consideration the potential threat to safety or life.

TOWARDS A NEW COLLABORATIVE APPROACH

Entegris proposes **a New Collaborative Approach** to examine the role of chemical, air, and gas contamination in the formation of defects undiscovered in the semiconductor manufacturing process.

Examining the Small, Medium, and Large of Increasing Automotive Device Reliability



Read the paper to learn more
www.entegris.com/automotive

*Process Watch: The Automotive Problem with Semiconductors. Electroiq website. http://electroiq.com/blog/2018 /01/process-watch-the-automotiveproblem-withsemiconductors/

Enriched ^{11}Boron Trifluoride and Hydrogen Mixture for Performance Improvement on Applied Materials E-500 Implanter

By Barry Chambers — Entegris, Inc.; Francisco E. Cruz Jr. — ABB Switzerland Ltd.

The following information was presented in a poster at the 22nd International Conference on Ion Implantation. Below is a summary highlighting key outcomes.

BACKGROUND

The presence of fluorine in the ion source arc chamber allows fluorine radicals to be created in the ion plasma. Through what is known as the halogen cycle, these radicals etch the relatively cooler tungsten or molybdenum arc chamber, or the arc chamber liner, and deposit the tungsten or molybdenum on the hotter filament in the ion source, increasing its mass. When the filament mass increases, the filament power supply cannot sufficiently heat the filament. This limits the generation of electrons needed to sustain the ion source plasma.

The addition of hydrogen to halogen-based implant source gases, such as BF_3, has been shown to effectively interrupt the halogen cycle.

SOURCE LIFE

The source life graph (Figure 1) shows an average life of 99 hours with $^{11}BF_3$. Once the $^{11}BF_3/H_2$ mixture was introduced, the average source life increased 111% to 209 hours (Figure 2). Reducing source changes by 50% and increasing uptime 1.7% allowed for more efficient use of technician time in maintaining the Implant module. Increasing uptime also provided additional time to process wafers, reducing module cycle time.

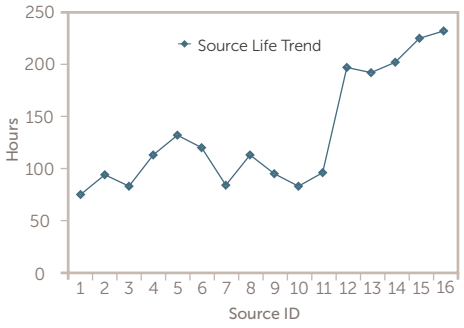


Figure 1. Source life trend

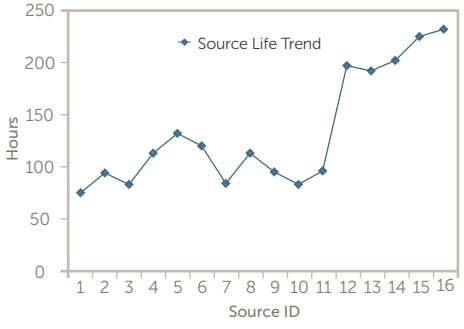


Figure 2. Box plot of source life

$^{11}BF_3$ MIXTURE SELECTION

Entegris offers more than one mixture to allow a single cylinder solution that is tailored to customer needs. Supplying the ideal mixture ratio in a single cylinder not only offers simplicity in use, it also removes the risk of a separate hydrogen cylinder and the risk associated with using two cylinders to accomplish the same benefit as a single VAC® cylinder. The $^{11}BF_3/H_2$ mixture gas is offered in the VAC package, which is a Subatmospheric Gas Sources (SAGS) Type II gas delivery system. The cylinder stores the gas mixture at a pressure greater than 500 psig, but delivers the mixture at a pressure of less than 14.7 psia. **The chemical stability of BF_3 and H_2 in this mixture is one of the most important safety and functional characteristics of this product.** Thermodynamic calculations, as well as experimental evidence, show that no reaction occurs between BF_3 and H_2 at room or elevated temperatures as exemplified by the reaction equation (1).

$BF_3(g) + 1.5H_2(g) = B(s) + 3HF(g)\ \Delta rG25°C = 293\ kJ$ (1)

For this reason, Entegris offers a 3 year shelf life on the VAC $^{11}BF_3/H_2$.

SUMMARY

The VAC $^{11}BF_3/H_2$ mixture has demonstrated a doubling of source life on an Applied Materials E-500 implanter. This resulted in more wafer turns due to increased tool availability, and also enabled a reduction in manufacturing cost per wafer based on extended use of the ion source components. This was accomplished with no negative impacts observed to beam current or sheet resistance.

As process controls increase to minimize process variation, the use of premixed process gases removes one source of implanter setup variation. This has the added benefit of less engineering intervention to maintain optimum implanter efficiency. The VAC $^{11}BF_3$ mixture allows customers to select the best mixture concentration for their specific process environment, with a package that is simple to install.

Furthermore, older designed implanter gas boxes typically only accept four cylinders. The VAC $^{11}BF_3/H_2$ mixture package can easily replace the existing BF_3 cylinder, allowing the user to realize the halogen cycle-inhibiting benefits associated with hydrogen.

For more details, download the full version Link

Realizing Bottom Line Profits from Wafer Carrier Selection

By Entegris Inc.

The global semiconductor industry is racing to address market demands for smaller, more powerful, and technology-laden devices. The role of front-end to back-end wafer handling carriers, advanced design criteria, and their impact on yields is ever increasing. The primary goal of the wafer carrier is to ensure safe transit, docking, loading/unloading, storage, and movement from point A to point B, all while maintaining the cleanliness of the wafer.

To assure leading-edge performance in defect protection, it is paramount to understand the contamination challenges in each step of the wafer's process journey and the benefits of choosing the right partner and products. The choice of wafer carrier expert can play a significant role in improving device yields. For the best results, manufacturers need to partner with a carrier expert who has an in-depth knowledge of material sciences and process control, and a history of design and innovation that can support the entire front-end to back-end device manufacturing process.

While it might seem to make sense to prioritize the carrier cost over all other factors, in reality, **it is equally important to control contaminants, quality, reliability, and availability. Calculations show that even a 1% improvement in yield can result in greater than $100 million in bottom-line profit for the device manufacturer.**

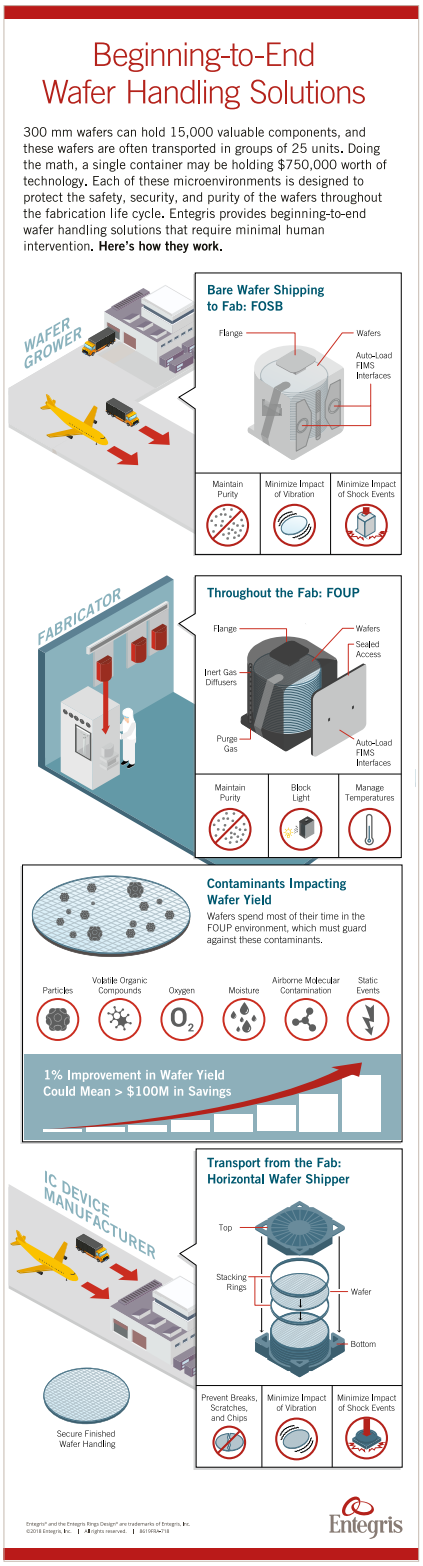
WILL YOUR CARRIER CHOICE IMPROVE YOUR BOTTOM LINE?

Not all carriers are the same in process control, contamination inhibition, cleanliness, usability, capacity, and durability, nor are all carrier vendors the same in terms of breath of product offerings. **Using carriers from several vendors increases the overall variability of contamination risk and vendor management challenges.** When choosing a front-end to back-end wafer carrier partner there are several key areas to consider in addition to the above technical requirements. Does your vendor meet all of them?

1. Industry leader with innovative solutions to meet the needs of the next-generation semiconductor products
2. Complete leading-edge front-end to back-end solution offerings
3. Delivers carriers on time with the highest quality and reliability
4. Local and attentive technical support
5. Ample capacity and backup manufacturing plans
6. Excellent cost of ownership.

A key strategy to improving yields is to **look for wafer carriers designed to meet the most stringent semiconductor specifications from a carrier partner that can provide not only the most advanced front-end to back-end carriers today, but also has the ability to design and deliver on the next generation products**.

For more details, download the white paper Link

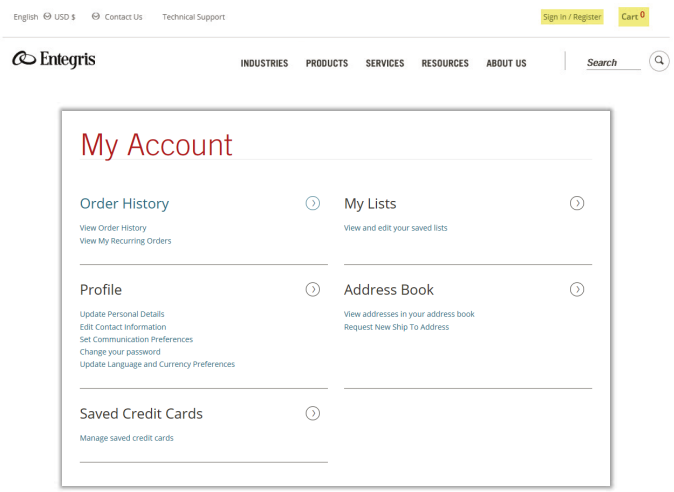


Entegris Launches Global E-Commerce Solution to Support Customer Needs

Entegris launched an online purchasing and transaction management system that provides full e-commerce capabilities for its customers.

Driven by customers' growing need for top-level efficiency and on-demand access to solutions, Entegris has launched a suite of tools to provide a robust e-commerce experience. This solution is fully integrated with Entegris's back-end systems to allow accelerated transactions, comprehensive transparency, and a convenient means to collaborate and do business.

"*Our e-commerce platform will provide customers with a seamless and efficient purchasing experience*," says Paul McSweeney, vice president of Global Sales Operations, Entegris. "***By registering online, our customers will have access to e-commerce purchasing via multiple channels; easy online account inquiry capabilities; on-demand order status with delivery tracking details; and secure file access to restricted manuals and other product-related collateral.***"



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