SMART®
Modular Technologies
A PENGUIN SOLUTIONS™ BRAND

Technical Brief

Enhancing Data Center Performance and Reliability with SMART's Conformally Coated DDR5 RDIMMs for Liquid Immersion Cooling

by Raghabendra Rout, Ph.D., New Product Engineer, SMART Modular Technologies

Introduction

As data centers face increasing demands for performance and energy efficiency, liquid immersion cooling has emerged as a promising solution. Liquid immersion cooling offers superior heat dissipation compared to traditional air cooling, allowing for higher density computing and improved energy efficiency. However, it also presents unique challenges for electronic components. SMART's conformally coated DDR5 RDIMMs address these challenges, by providing a reliable memory solution which allow the memory modules to operate effectively in immersion-cooled servers.

SMART Modular Technologies' conformally coated DDR5 RDIMMs represent a significant advancement in memory solutions for liquid immersion-cooled data centers. By combining DDR5 performance with enhanced protection against the unique challenges of immersion environments, these modules enable data centers to push the boundaries of computing power while ensuring long-term durability and reliability at the same time. For data center operators looking to leverage the benefits of liquid immersion cooling, SMART's RDIMMs offer a compelling solution that addresses key concerns around component longevity, performance, and maintenance costs.

The conformal coating process significantly improves the durability of DDR5 RDIMMs in liquid immersion environments in several key ways:

1. **Corrosion resistance:** The coating shields sensitive electronic components from corrosive elements present in the immersion coolants. This protection extends the lifespan of the memory modules by preventing chemical interactions that could degrade materials like plastics and metals used in RDIMM modules.

2. **Moisture ingress prevention:** Conformal coating helps prevent the invasion of moisture, which is a critical factor in liquid immersion environments. By sealing out moisture, the coating reduces the risk of short circuits and other moisture-related failures.

3. **Material compatibility:** The conformal coating addresses concerns about material compatibility between RDIMMs and the dielectric fluids used in immersion cooling. It prevents potential chemical reactions that could lead to swelling, creep behavior, or other forms of material degradation.

4. **Improved thermal stability:** The coating provides excellent thermal stability, making these modules ideal for the consistent thermal environment of liquid immersion systems. This stability reduces the risk of thermal hotspots and enhances overall system reliability.

5. **Long-term reliability:** By protecting against various environmental factors, the conformal coating significantly enhances the long-term reliability of RDIMMs. This is crucial for data center applications where component longevity directly impacts operational costs and system uptime.

6. **Reduced maintenance requirements:** By protecting against corrosion and environmental factors, conformal coating leads to higher reliability and lower maintenance costs for data center operators.

7. **High-performance DDR5 technology:** These modules leverage the latest DDR5 technology, offering superior speed and efficiency for demanding workloads such as AI, machine learning, and high-performance computing.

8. **Large memory capacity:** With support for up to 256GB per module, SMART's RDIMMs provide the substantial memory capacity required for data-intensive applications in modern data centers.

How Conformal Coating Works

The conformal coating process for memory modules is critical to improve the durability of electronic devices and printed circuit board assemblies (PCBA), by forming a thin layer of polymeric film to safeguard the components from external environmental conditions such as tin whisker growth, sulfur rich atmosphere, contaminants, dirt, impact of subsequent shock and vibration, static induced etc.

- **Conformal coating material is applied using a spray coating:** A thin, uniform layer is sprayed onto the surface of two sides of the memory module. SMART employs automated spraying, considered the most accurate dispensing process to achieve uniform coating thickness across the product without compromising product quality and reliability. Due to its precise application, high throughput and repeated processing, this method is preferred in comparison to other methods (dipping, brushing) on different product form factors.

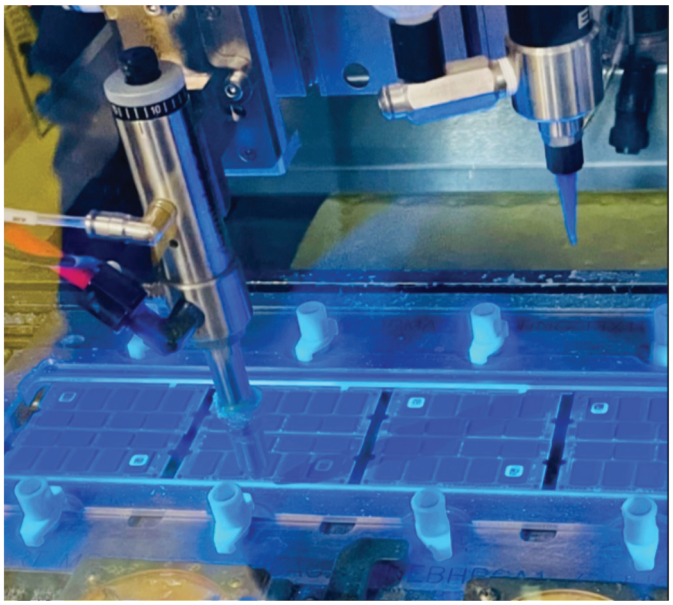

Figure 1: Spray coating process to apply coating material uniformly on PCBA surface

- **Coating Material:** Choosing the right material for conformal coating process is very critical. Based on application of product and real time service use, primary factors used for selection of conformal coating material are contaminations due to chemical, temperature and humidity. Based on experimental design, Polyurethane is used because of its advantages in moisture, abrasion and chemical resistance.

Process Steps

1. **Cleaning:** The cleaning steps are vital to the conformal coating process.

   a. Initial cleaning is for preventing contaminants such as flux residues, dust, and other particles from the assembly process that can compromise the adhesion of conformal coatings to the PCB surface. Weak adhesion may result in the coating peeling off, diminished moisture protection and heightened vulnerability to corrosion.

   b. Second, the memory modules are thoroughly cleaned using an aqueous chemical wash process to remove any contaminants

   c. The memory modules are then baked to absorb any solvents on the PCBA surface. This process removes moisture, preventing delamination and outgassing, while also extending the PCB's lifespan and improving its performance in the device.

   d. Memory modules are subsequently treated with a plasma process to enhance PCB surface adhesion (wettability/ hydrophilicity behavior), better solderability, reactivity, reducing defects.

   e. Lastly, a contact angle measurement technique is used to assess the wettability behavior of the plasma etched surface.

2. **Ionograph ROSE testing:** This step is required to analyze and evaluate the total ionic contamination on the PCB surface, post cleaning process.

3. **Masking:** Areas that should not be coated (e.g., connectors, gold fingers, tooling holes) are masked off so they are not coated and will operate effectively.

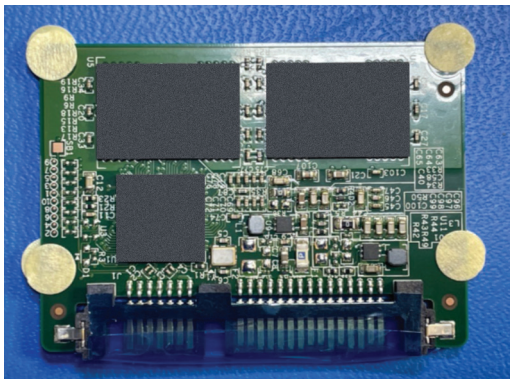

Figure 2: Example showing masking process to avoid sipping of conformal coating material into gold finger areas

4. **Coating material application:** Conformal coating is applied through different methods like brushing, spraying, dipping, selective, or curtain coating to protect the PCB and improve its reliability. For effective coating process, spray coating is used to uniformly deposit the coating material across the PCB surface to meet optimum coating thickness as per IPC-CC-830 and IPC-A-610 standards.

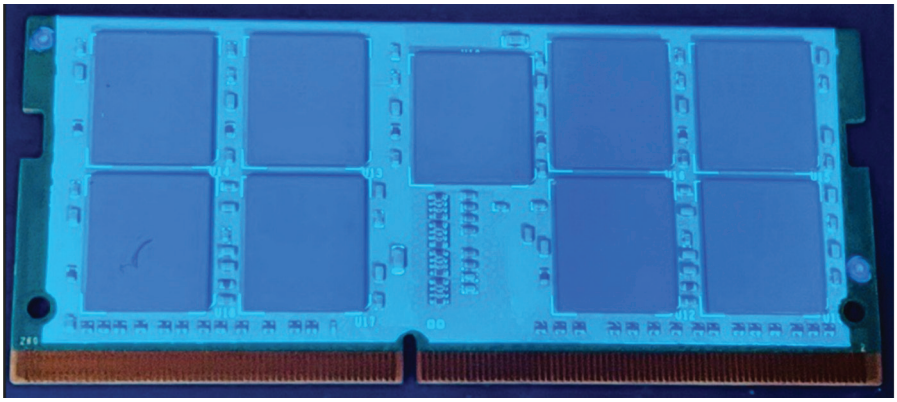

Figure 3: Example showing conformal coated module under UV light inspection

5. **Curing:** The coating is cured using heat, UV light, or chemical processes, depending on the coating material and the application.

6. **De-masking:** Protective masks are removed from areas that were not coated.

7. **Inspection:** Inspecting conformal coated modules involves verifying uniform coverage, correct thickness, and the absence of coating defects such as bubbles or cracks. The modules are inspected under UV light microscope to check the coverage. Under UV light, the module glows in blue color which allows for visual inspection to confirm that the coating is complete entirely and intact to PCB surface.

Conclusion

As data centers increasingly turn to liquid immersion cooling for enhanced performance and energy efficiency, this method presents unique challenges for electronic components. SMART's conformally coated DDR5 RDIMMs tackle these challenges by ensuring reliable operation in immersion-cooled servers. By addressing critical aspects such as protection and durability, the conformal coating process allows SMART's DDR5 RDIMMs to excel in liquid immersion environments, ensuring both long-term durability and high performance in demanding data center applications.

SMART® Modular Technologies
A PENGUIN SOLUTIONS™ BRAND

For more information, please visit: **www.smartm.com**

**Product images are for promotional purposes only. Labels may not be representative of the actual product.*

Headquarters/North America:
T: (+1) 800-956-7627 • T: (+1) 510-623-1231
F: (+1) 510-623-1434 • E: info@smartm.com

Latin America:
T: (+55) 11 4417-7200 • E: sales.br@smartm.com

Asia/Pacific:
T: (+65) 6678-7670 • E: sales.asia@smartm.com

EMEA:
T: (+44) 0 7826-064-745 • E: sales.euro@smartm.com

Customer Service:
T: (+1) 510-623-1231 • E: customers@smartm.com

10.06.24/DIMMSLiquidCoolingTechBrief/Rev.2