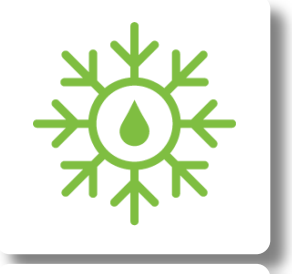
Cooling Environments





Material Compatibility and Long-Term Hardware Integrity of Enterprise SSDs in Two-Phase Immersion Cooling

Immersion Project

Youngnam Kim

Samsung Electronics

OCP PLATINUM Member

2Phase Immersion Ecosystem

Partners



Roles

Samsung — Device

High-Performance Enterprise SSD Development

Chemours — Coolant

Opteon 2P50: Next-gen 2-Phase dielectric coolant

Liquid Stack — Infrastructure

2Phase Immersion tanks for production DCs

PKI — Operation

Immersion Cooling Infrastructure Operations

Long-term Reliability Test Environment

48U 2Phase-Immersion Cooling Tank

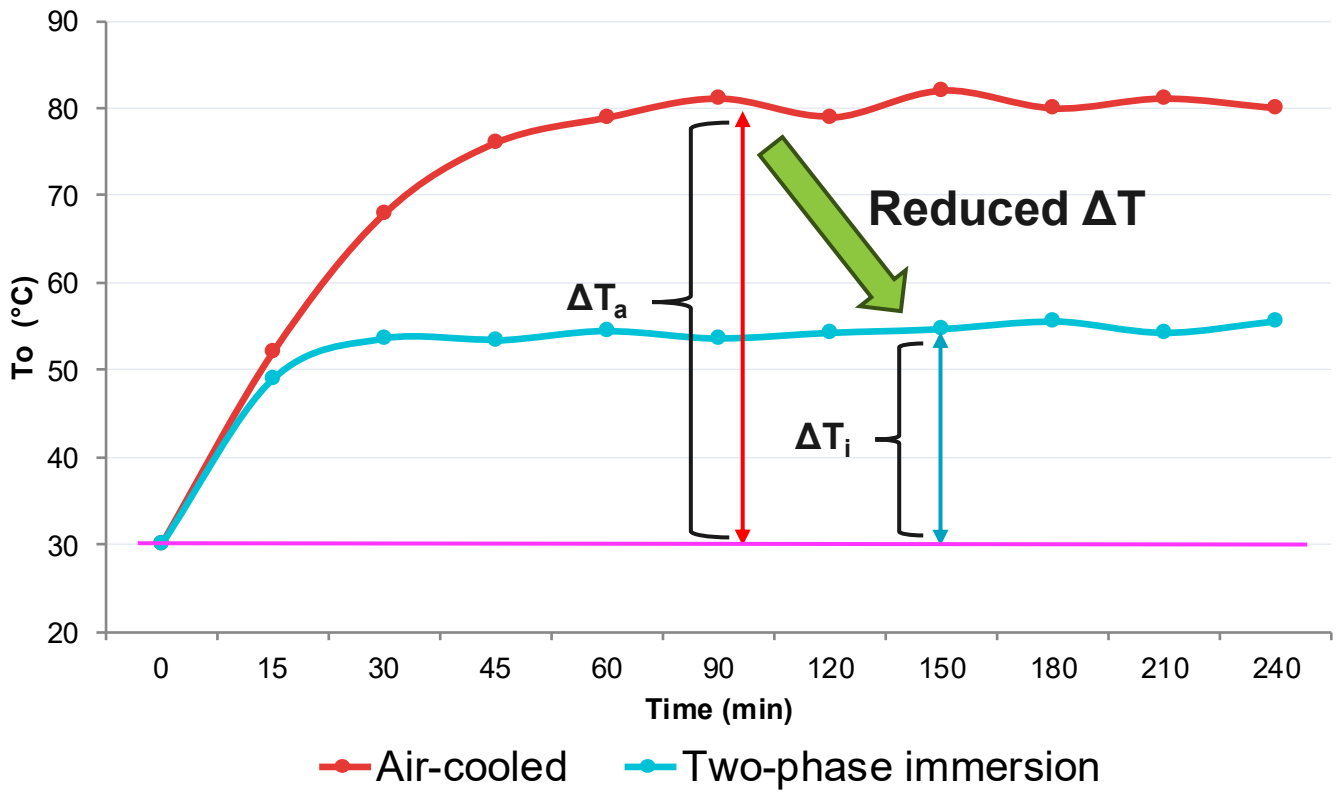


Operational Status Summary

Item	Spec.	Status
	Samsung High-performance Gen4 & Gen5 Enterprise SSDs	**Active**
	Liquid Stack 48U 2Phase Immersion Cooling Tank	**Active**
	> 15,000 Hours (Ongoing)	**Stable**
	Chemours Specialized 2Phase Dielectric Coolant Opteon 2P50	**Stable**
	0% Failure Rate (Under JESD219)	**Excellent**

Mechanical Reliability Paradigm Shift

SSD Operating Temperature (T_o) : Air vs Immersion



Key Observations

- Under JESD219 (SSD Endurance Workloads) 2-Phase immersion cooling **dramatically reduces ΔT** vs air cooling.

- Spatial/temporal uniformity across SSD components is **significantly improved**.

※ This work focuses on thermo-mechanical behavior; signal integrity is out of scope.

Implication

New bottleneck: chemical compatibility

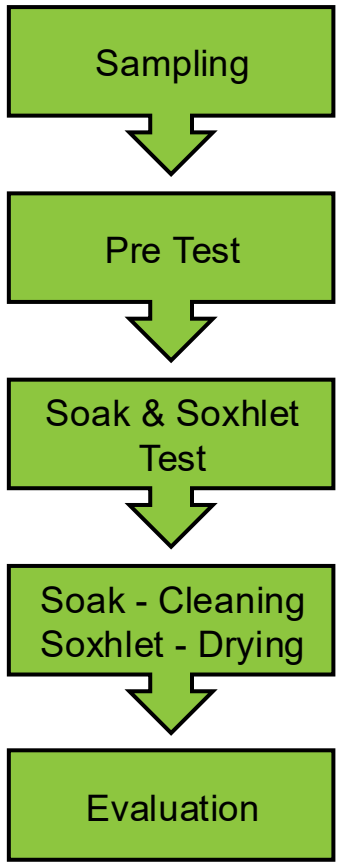
Lower ΔT reduces mechanical strain, setting the stage for chemical compatibility to become the new reliability bottleneck in Immersion Cooling.

Material Compatibility Test Methodology

Material Compatibility Samsung Spec

Details	OCP Guide For 2PIC	Samsung Spec For 2PIC
Target	Material	Material + **Product**
Test Method	Soxhlet	1) Soxhlet **2) Soak**
Test Temp	Boiling Point (30~60℃)	1) Boiling Point - Soxhlet **2) 80℃ - Soak**
Test Duration	48hrs	1) 72hrs Soxhlet **2) 336hrs Soak**
Criteria (Acceptable)	△ Weight < 2% △Extracts < 2%	△ Weight < 2% △ Extracts < 2% **Operating Test Pass**

Methodology





<Soak Test>



<Soxhlet Test>

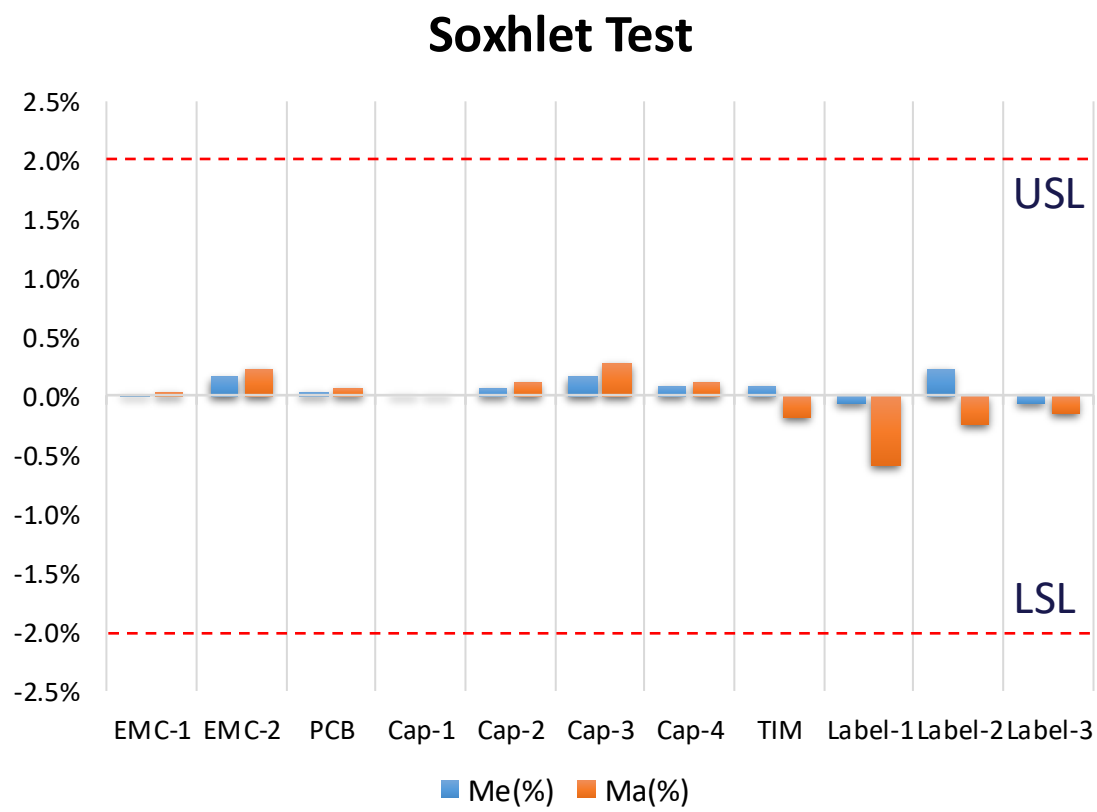
Material Compatibility Test Result

Soxhlet Test Result

- Materials : From EP SSDs, -Temperature : 49℃(B/P)
- Coolant : Chemours Opteon 2P50, -Duration : 72hrs

Materials	Appearance	Mass Change	
		72hrs	Result
Capacitors	No Change	△ Mass < 2%	**PASS**
Labels	No Change	△ Mass < 2%	**PASS**
EMCs	No Change	△ Mass < 2%	**PASS**
PCB	No Change	△ Mass < 2%	**PASS**
TIM	No Change	△ Mass < 2%	**PASS**

Mass Change after Soxhlet Test(%)



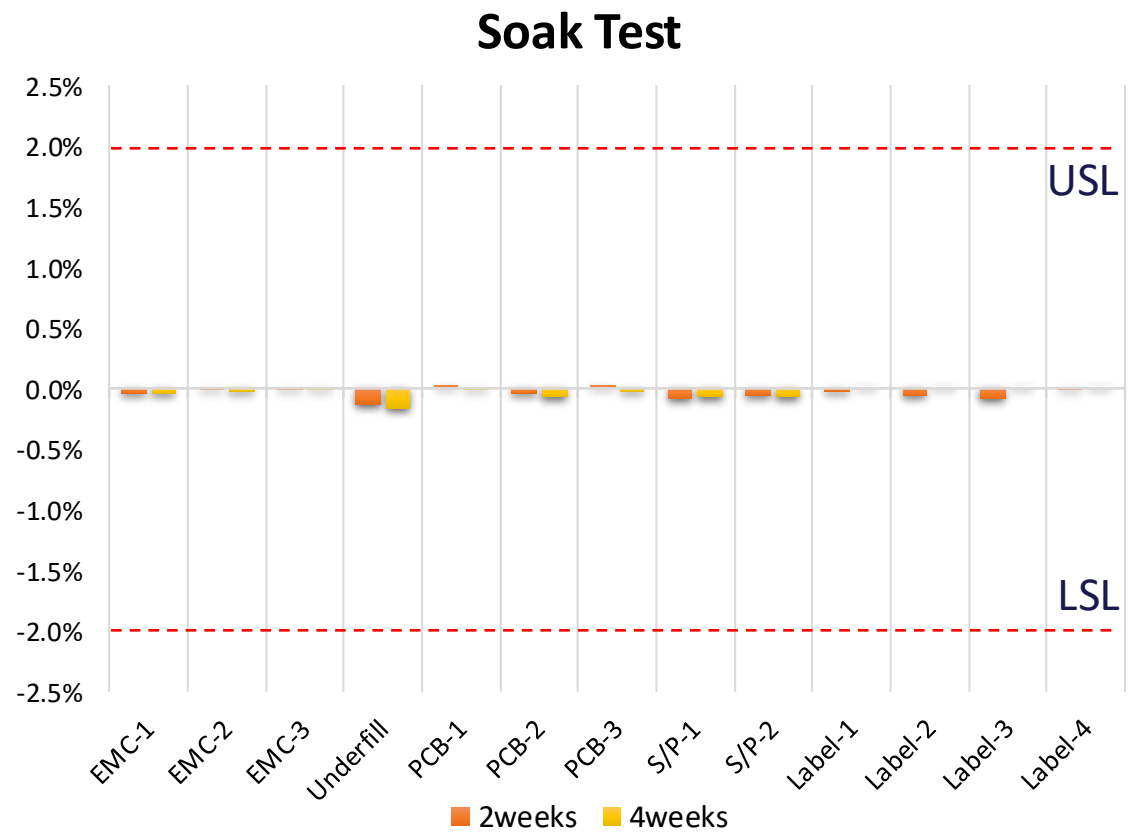
Material Compatibility Test Result

Soak Test Result

- Materials : From Samsung EP SSDs, - Temperature : 80℃
- Coolant : Chemours Opteon 2P50, - Duration : 2wk, 4wk

Materials	Appearance	Mass Change		
		2weeks	4weeks	Result
Capacitors	No Change	△ Mass < 2%	△ Mass < 2%	**PASS**
Labels	No Change	△ Mass < 2%	△ Mass < 2%	**PASS**
EMCs	No Change	△ Mass < 2%	△ Mass < 2%	**PASS**
Underfills	No Change	△ Mass < 2%	△ Mass < 2%	**PASS**
PCBs	No Change	△ Mass < 2%	△ Mass < 2%	**PASS**
S/Pastes	No Change	△ Mass < 2%	△ Mass < 2%	**PASS**
TIMs	No Change	△ Mass < 2%	△ Mass < 2%	**PASS**
***Products**	No Change	△ Mass < 2%	△ Mass < 2%	**PASS** (Working)

Mass Change after Soak Test(%)

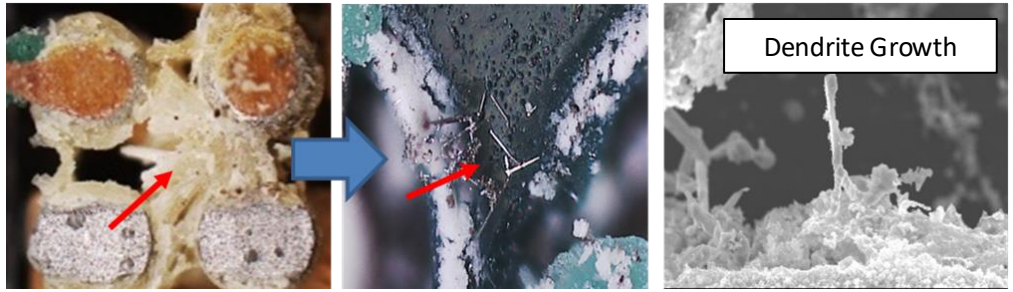


Observed SSD-Level Risks

Contamination-Induced Failure

■ **Coolant Contamination Risk**

- Burn-out failure observed on high-power IC and fine-pitch BGAs.



■ **Failure Mechanism**

1) Contamination

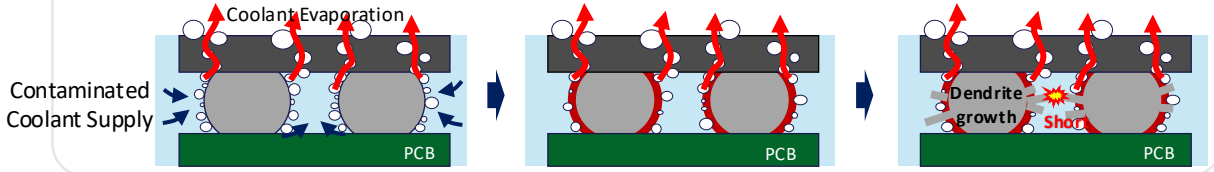
- Flux residues and PCBA-origin ions migrate into the coolant.

2) Deposition

- Contaminants condense on high-power PKGs at boiling sites.

3) Failure

- Dendrite growth bridges adjacent balls → short-circuit → burn-out.



Solder joint surface contamination occured

PCBA Cleaning Process

■ Removes SMT-origin ionic residues before SSD enters the immersion cooling tank

■ Aqueous wash → DI rinse → controlled dry (verified per IPC-TM-650)

■ Coolant purity preserved : 0% failure across 15,000+



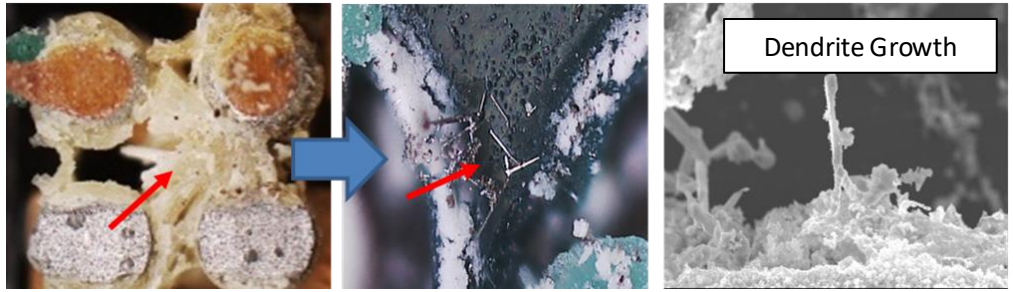
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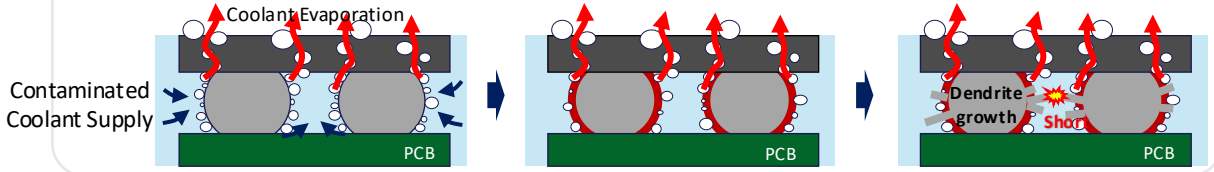
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To Summarize

- One. Immersion cooling dramatically reduces thermo-mechanical stress.
- Two. Samsung SSD materials are compatible with Chemours Opteon 2P50.
- Three. The remaining risk is cleanliness, and we control it before the product goes int the tank

Call to Action

- One. Let's extend the OCP material test guide to the product level.
- Two. Let's add a PCBA cleaning specification to the guide.
- Three. Please join the OCP Immersion project and work with us.

Immersion Ecosystem partners

Chemours™ liquidstack° pki Shell HD HYUNDAI OILBANK GS Caltex S-OIL

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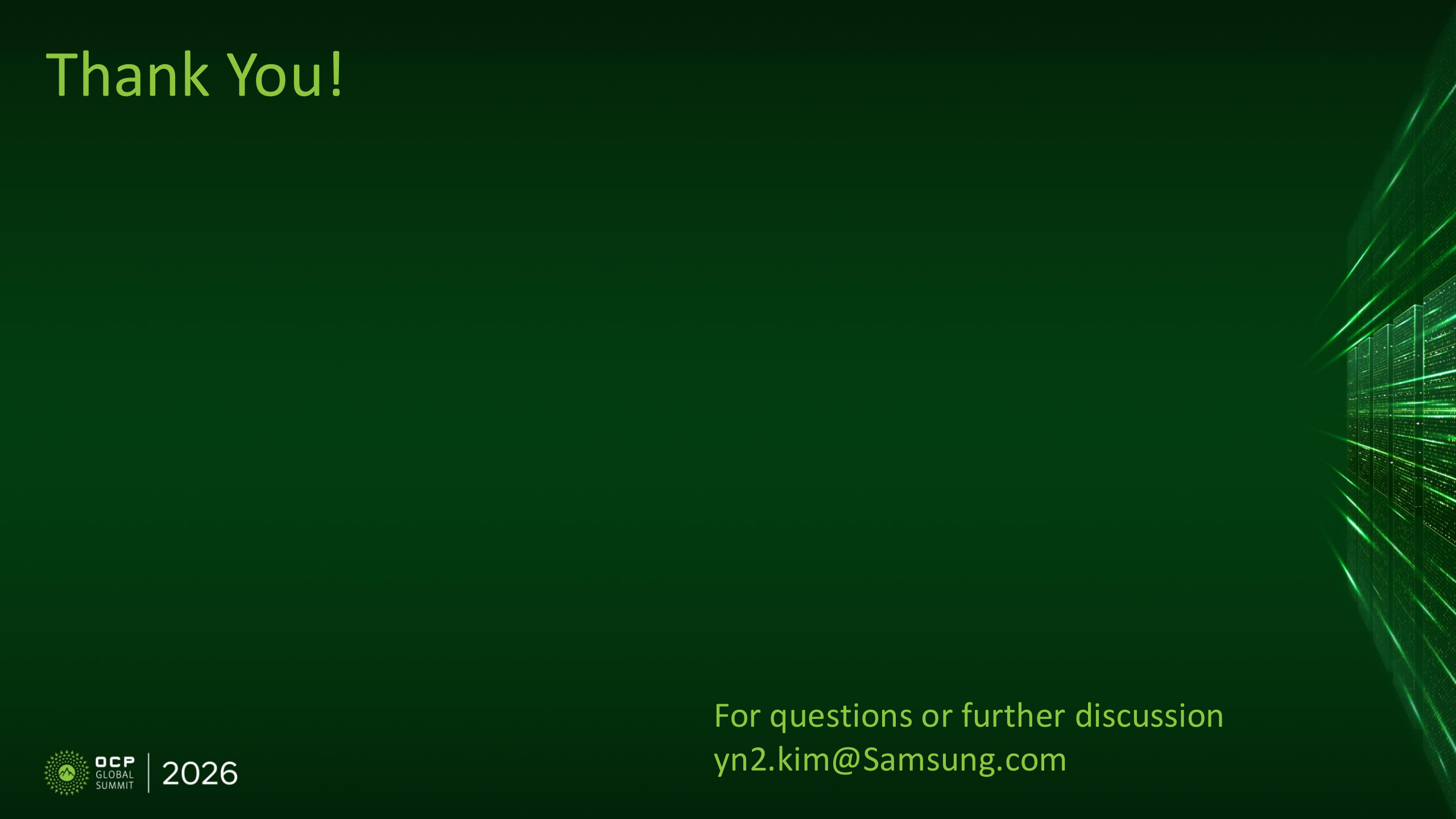
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Thank You!



For questions or further discussion
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