

Evaluation of Cold-Sprayed A6061 and 99.7% Aluminum Coatings Experimental Assessment of Pre-Spray Conditions for LNG Cryogenic Pump Maintenance

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Cold Spray Club 2025

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About Plasma Giken

- Founded in 1980
- Over 20 years experience in the development of in Thermal Spraying /Cold Spray Technology
- Delivering high-quality thermal spray technologies that enhance the performance, durability, and reliability of components across various industries
- We want to provide benefits such as high deposition rates, minimal substrate heating, and exceptional coating quality.
- Applications in aerospace, automotive, defense, oil and gas, and many other sectors.



- Requirements:
- 1. Spray Material:** A6061 or pure Aluminum
 - 2. Bonding Strength:** Greater than 30 MPa
 - 3. Porosity:** Less than 5%
 - 4. Surface Finish:** Smooth surface preferred for effective sealing of high-pressure gas with an O-ring

Specifications: PCS-1000v2 and PCS-100

Chamber Gas Temperature	1100°C
	2021°F
Chamber Gas Pressure	7.5 MPa
	75 Bar
	1087 PSI
Powder Feed Rate	0-500 g/min
Time to Reach Steady State	3-5 minutes

* Multi Powder Feeder Operation Optional
N2 & He Mixing Optional



PLASMA

Cold Spray System

PCS-1000v2 Gun / PCS-100 Gun
PGU-100 Gas Controller / PGC-100 Touch Panel / POG-2030 Powder Feeder

Plasma Giken Co., Ltd.
<http://www.plasma.co.jp/en/>

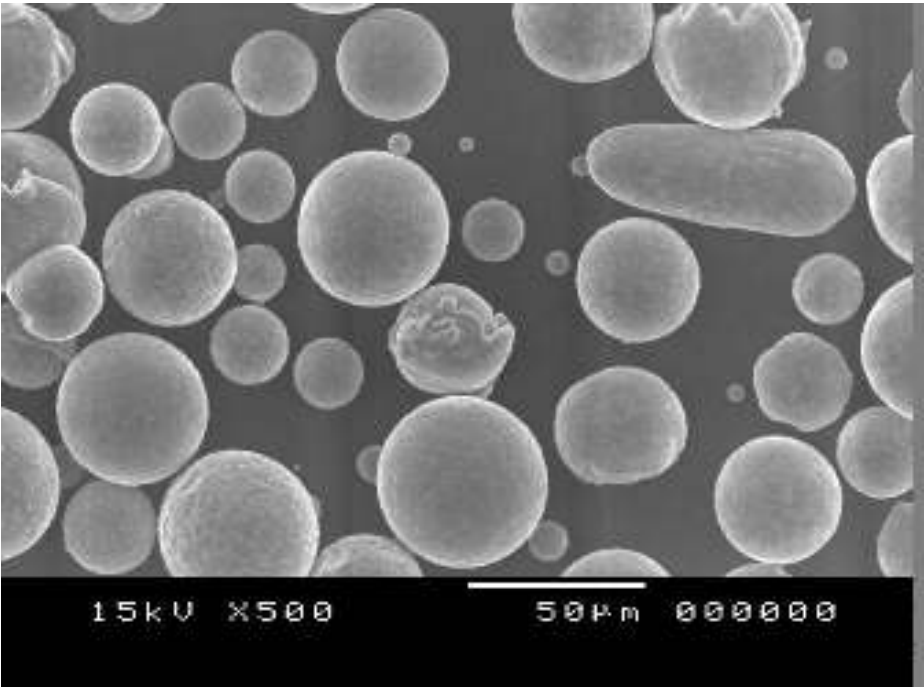
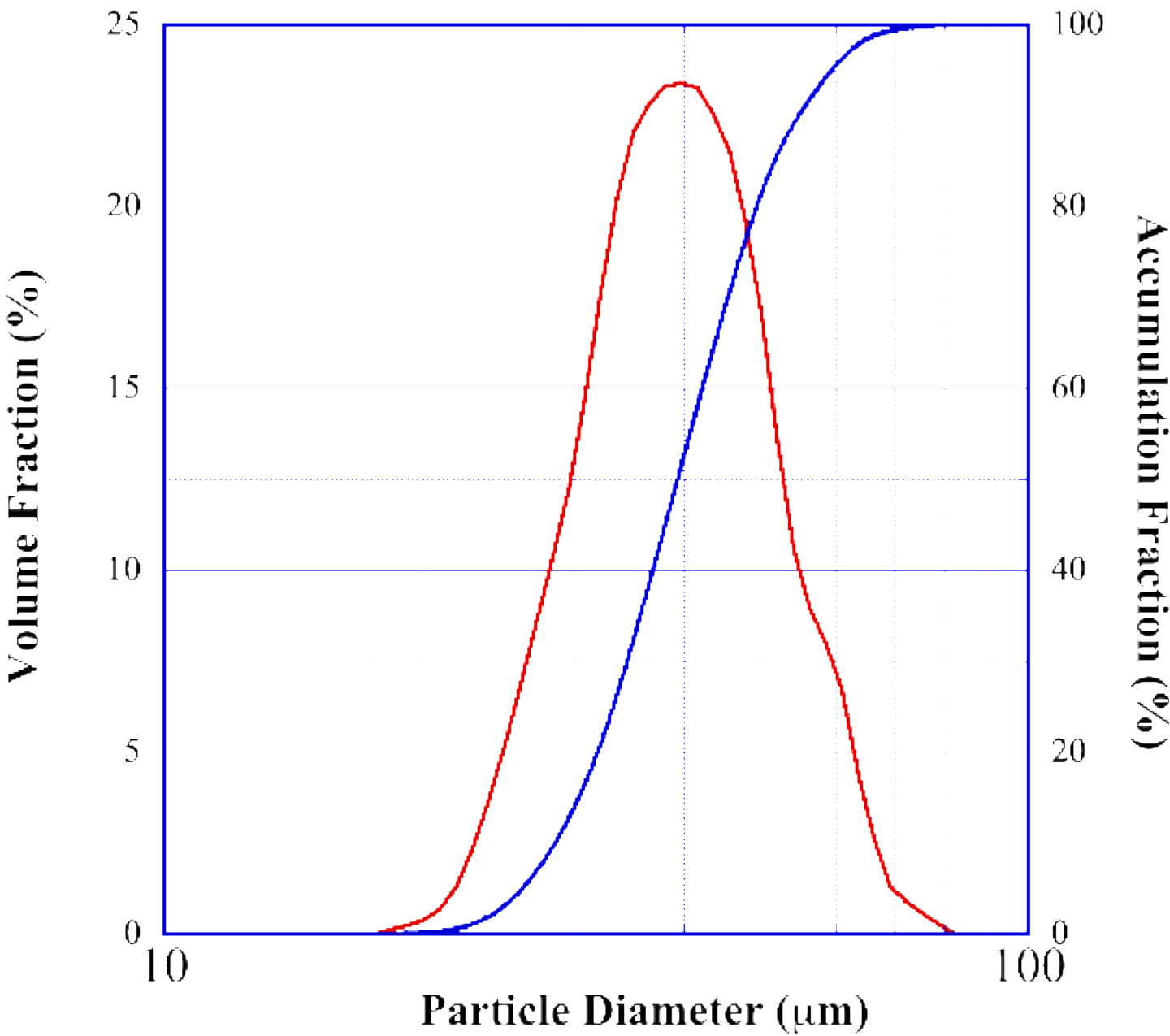
99.7% Al Chemical Composition

1.合金成分 (wt%)

仕様	Si	Fe	Cu	Zn	Mn	Mg	Ni			その他	Al
Q11番号	<0.15	<0.2	<0.02	<0.02	<0.02	<0.02	<0.02			<0.05	>99.7
22K25413	0.023	0.07	0.001	0.001	0.001	0.001	0.003			0.002	99.89

99.7% Al Powder Particle Size Distribution

— Fraction — Accumulation



Particle Morphology

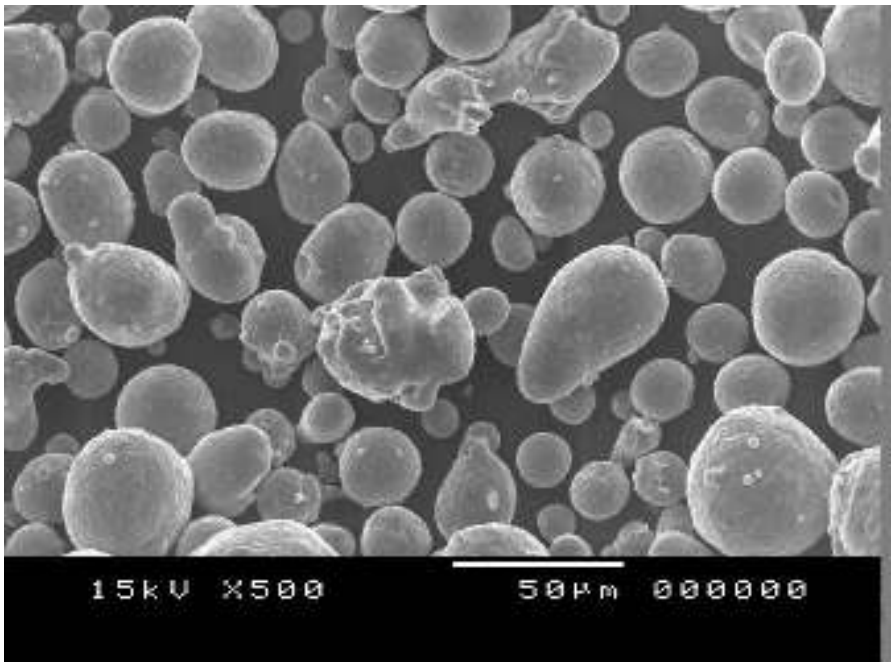
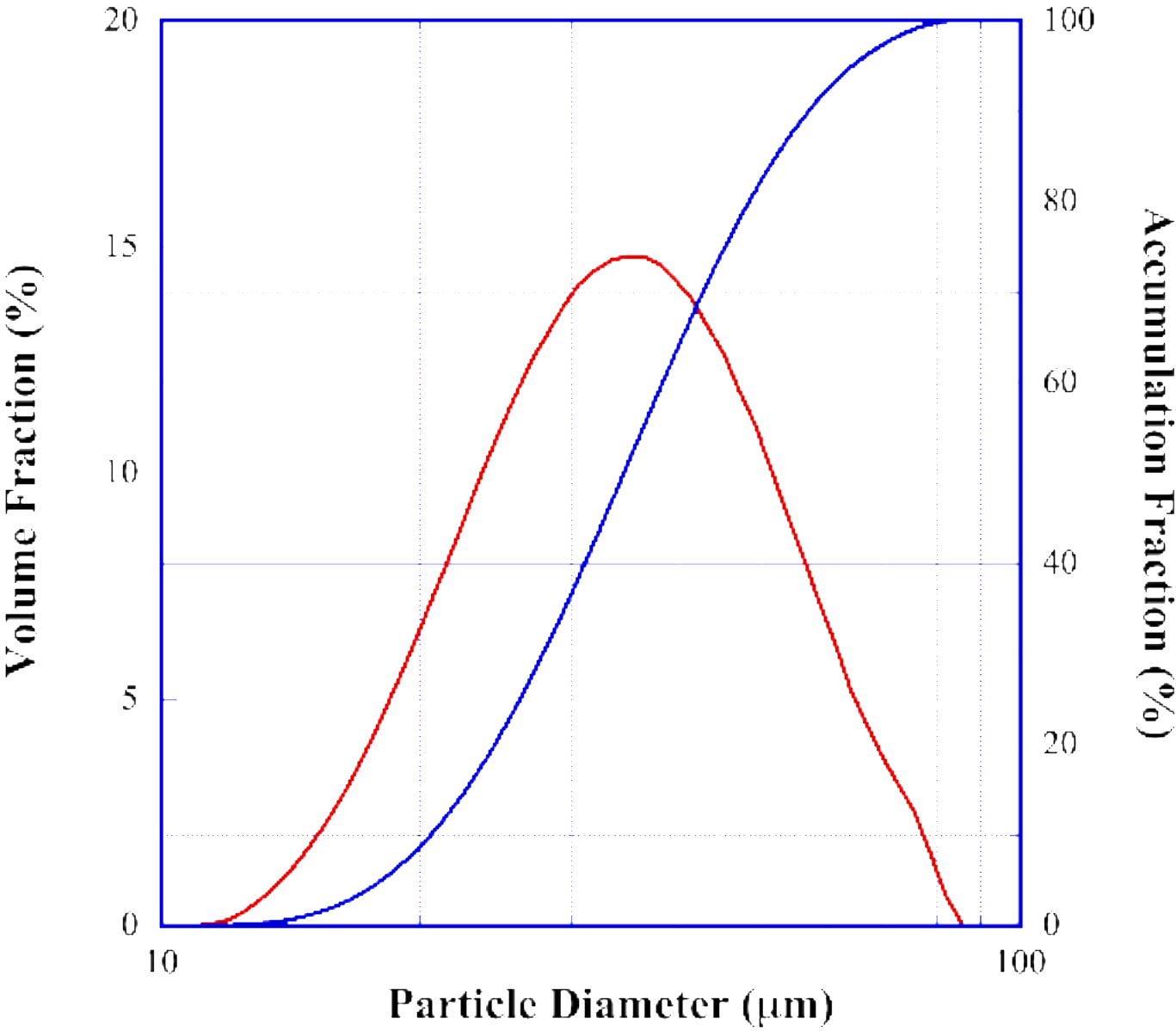
Specification : AM 6061

Chemical Analysis
(ICP-OES)(Leco)

% : Bal.	%Cr : 0.13	%Cu 0.26	%Fe : 0.14	%Mg 0.87	%Mn : <0.01
%N :	%Ni :	%O :	%Pb :	%Si 0.62	%Sn :
%Ti 0.01	%Zr :	%Zn <0.01	Others Each : <0.05	Others Total : <0.15	

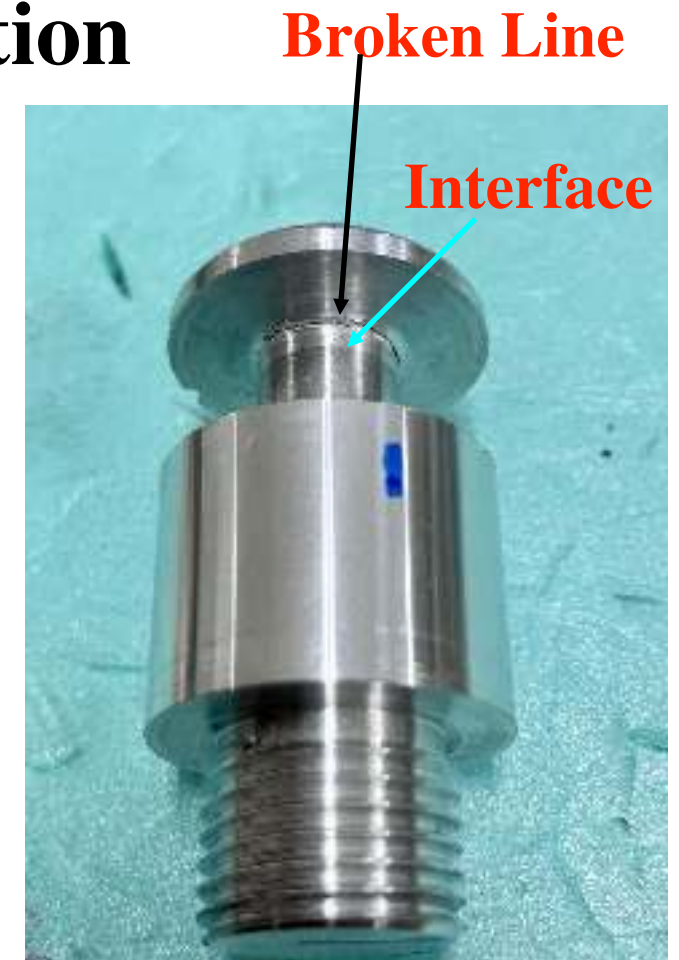
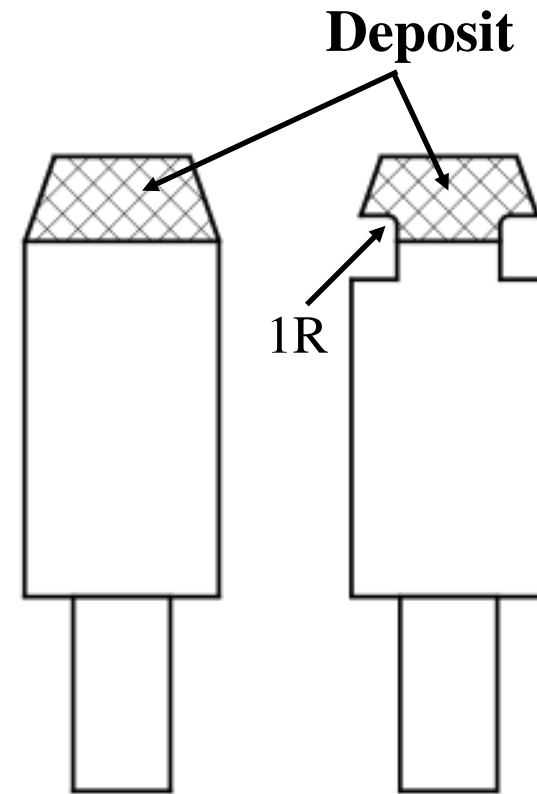
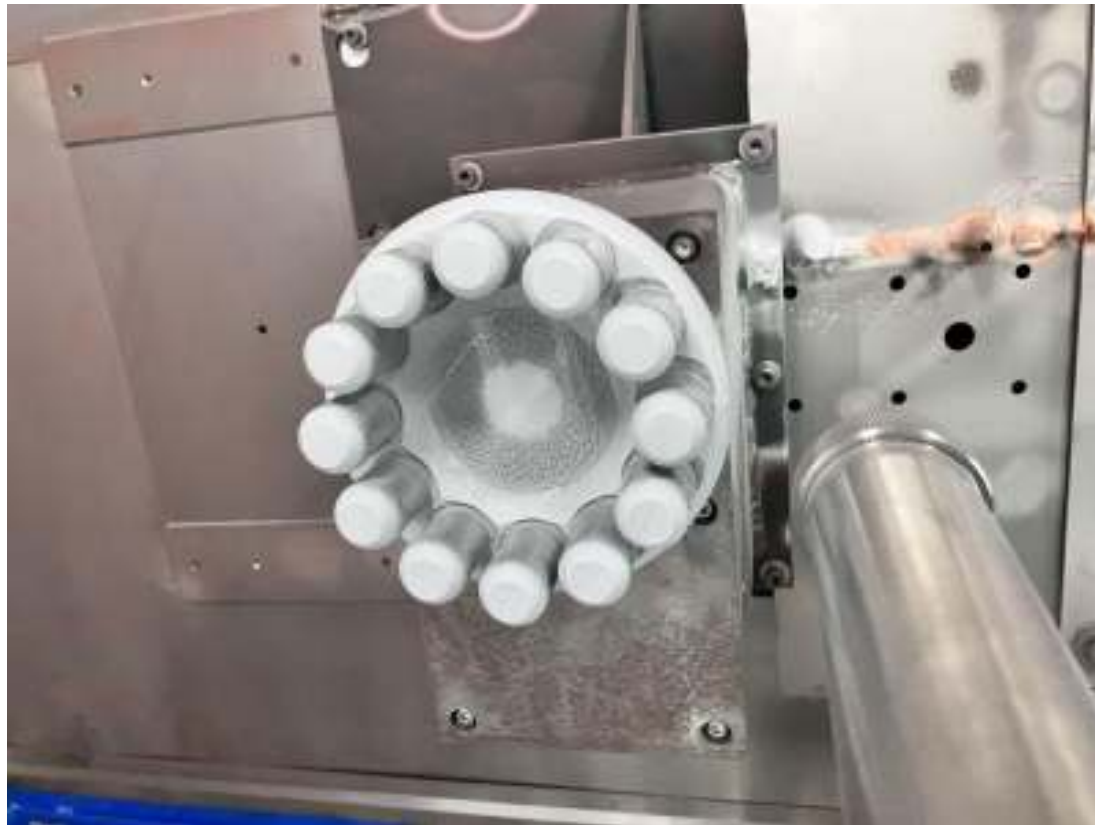
A6061 Powder Particle Size Distribution

Fraction **Accumulation**



Particle Morphology

Bonding Strength Measurement: Experimental Setup and Specimen Preparation



Spray Conditions

Operating Gas: He gas

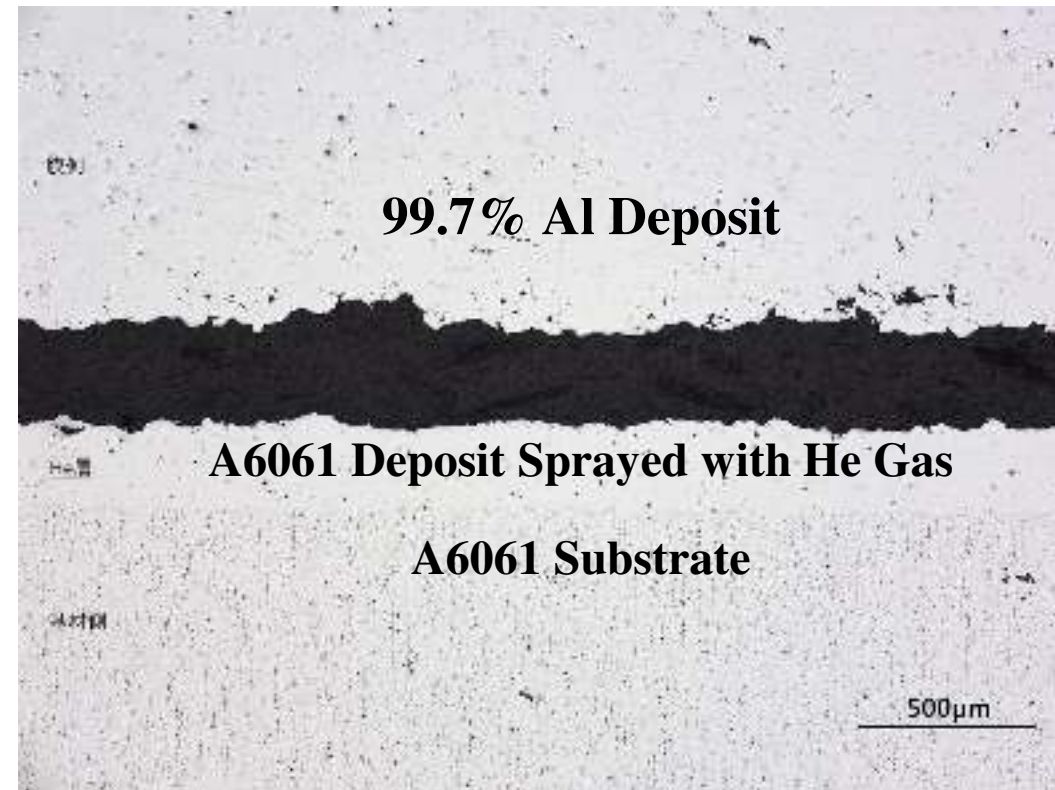
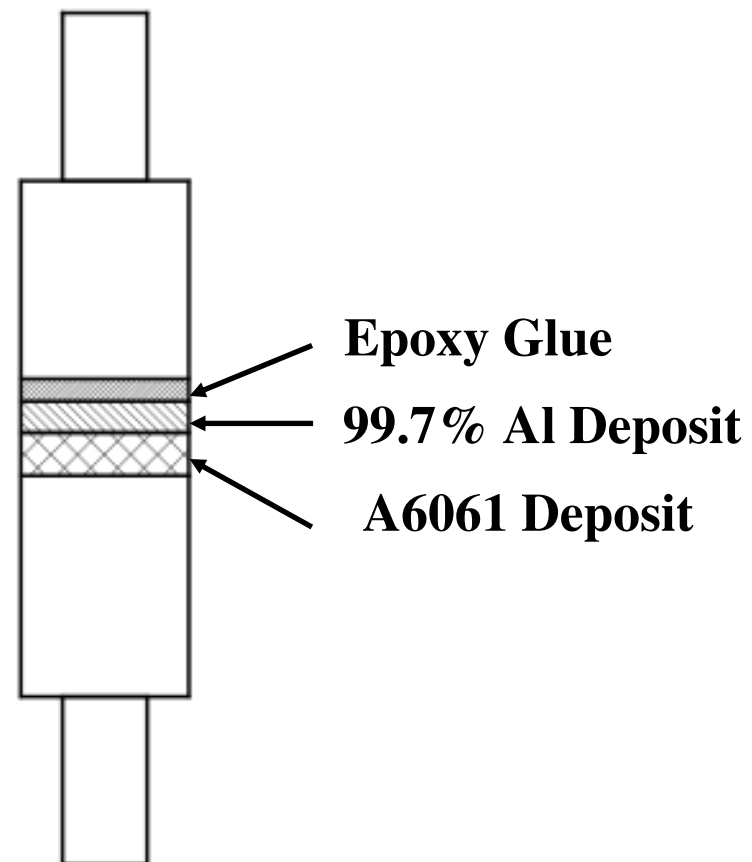
Chamber Gas Temperature: 400°C

Chamber Gas Pressure: 4MPa

Spray Distance: 30 mm

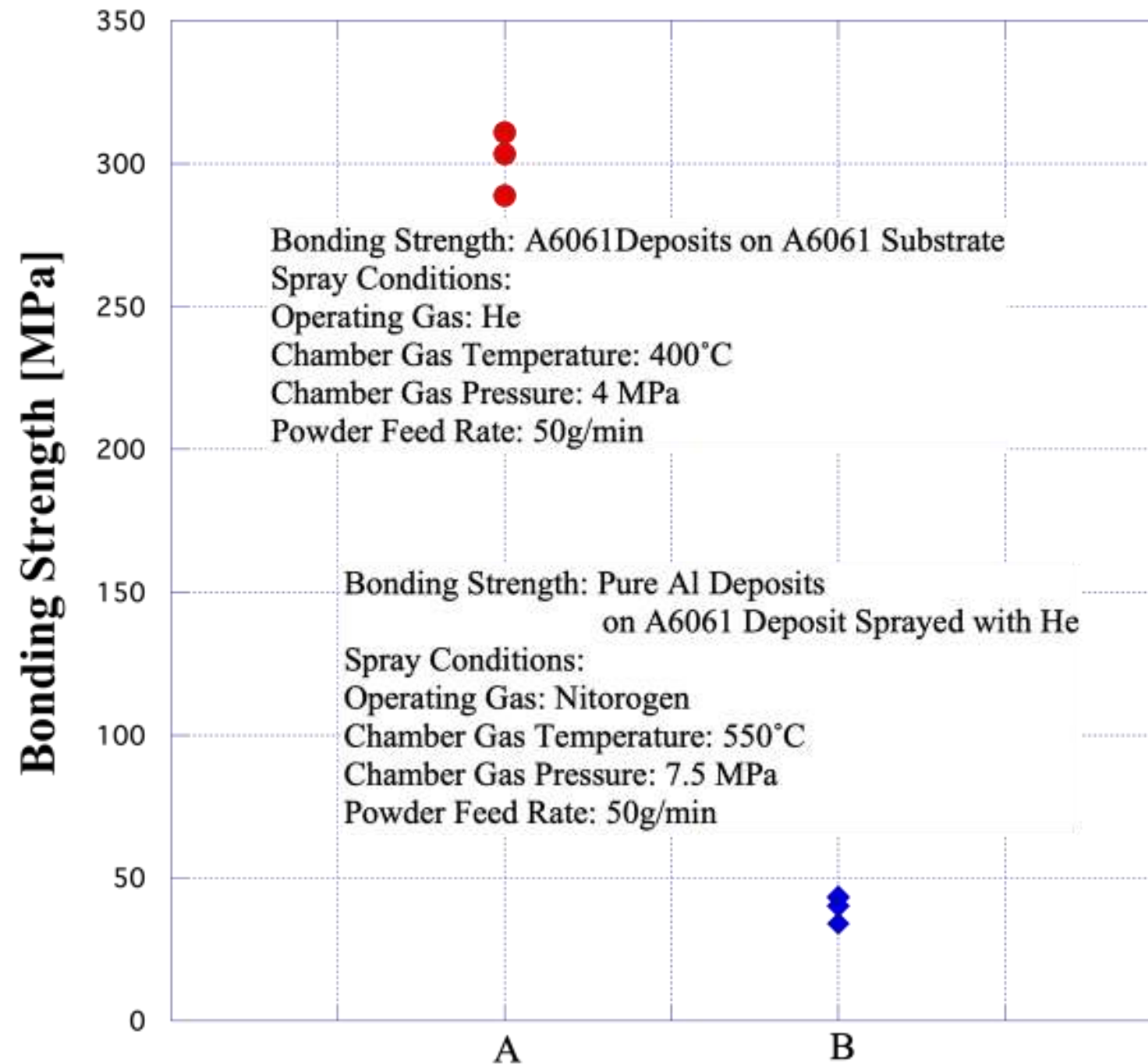
Specimen Table Rotating Speed: 60 rpm





Ruptured Interface

Bonding Strength



Results:

A6061 → A6061 (Group A Red):

- Very high bonding strength (around 300 MPa) (Helium as carrier gas at lower temperature and pressure).

99.7% Al → A6061 (Group B Blue):

- Higher pressure and temperature. But lower bonding strength (under 50 MPa, but above 30MPa).

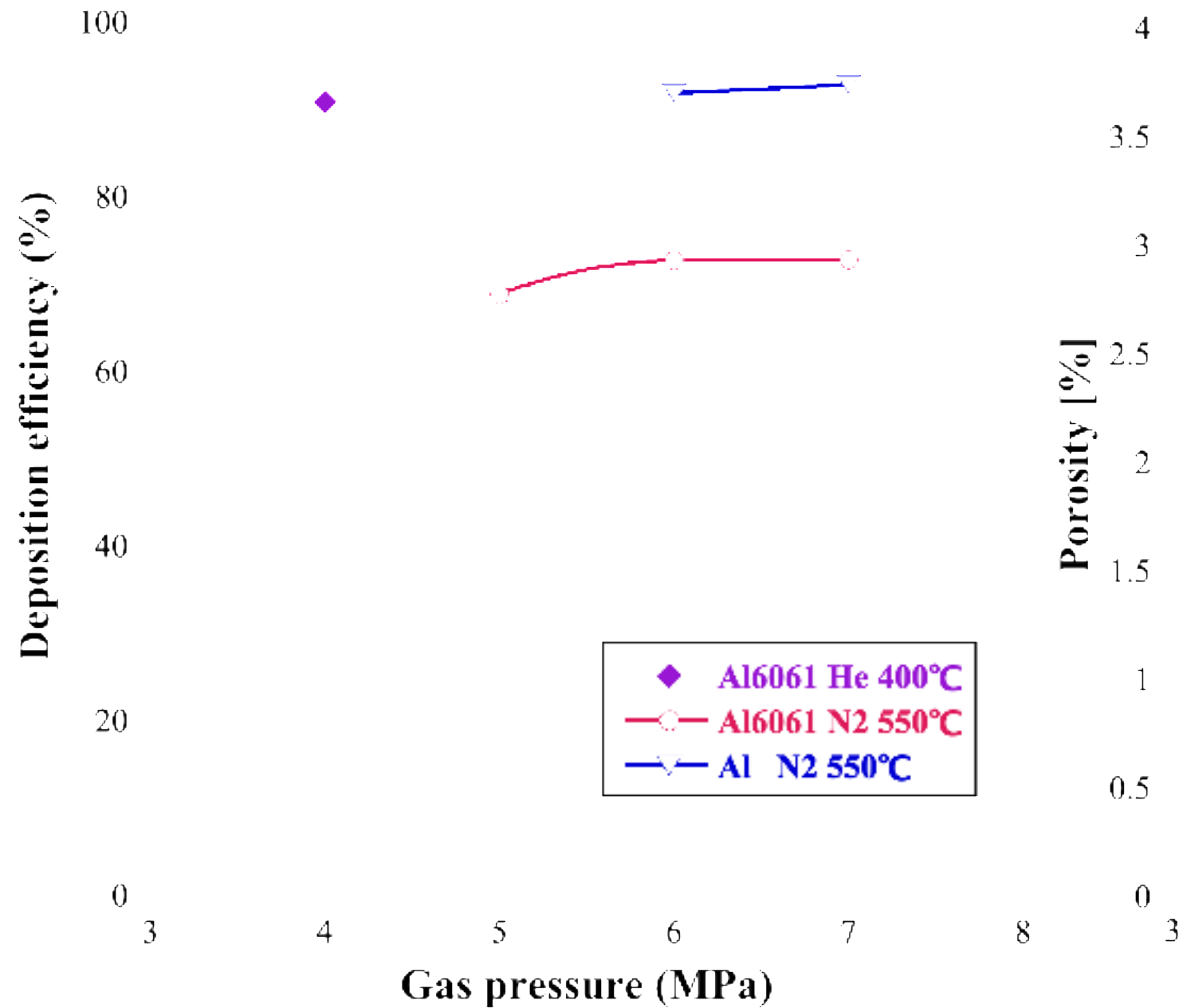
Deposition Efficiency and Porosity Measurement

Spray Conditions

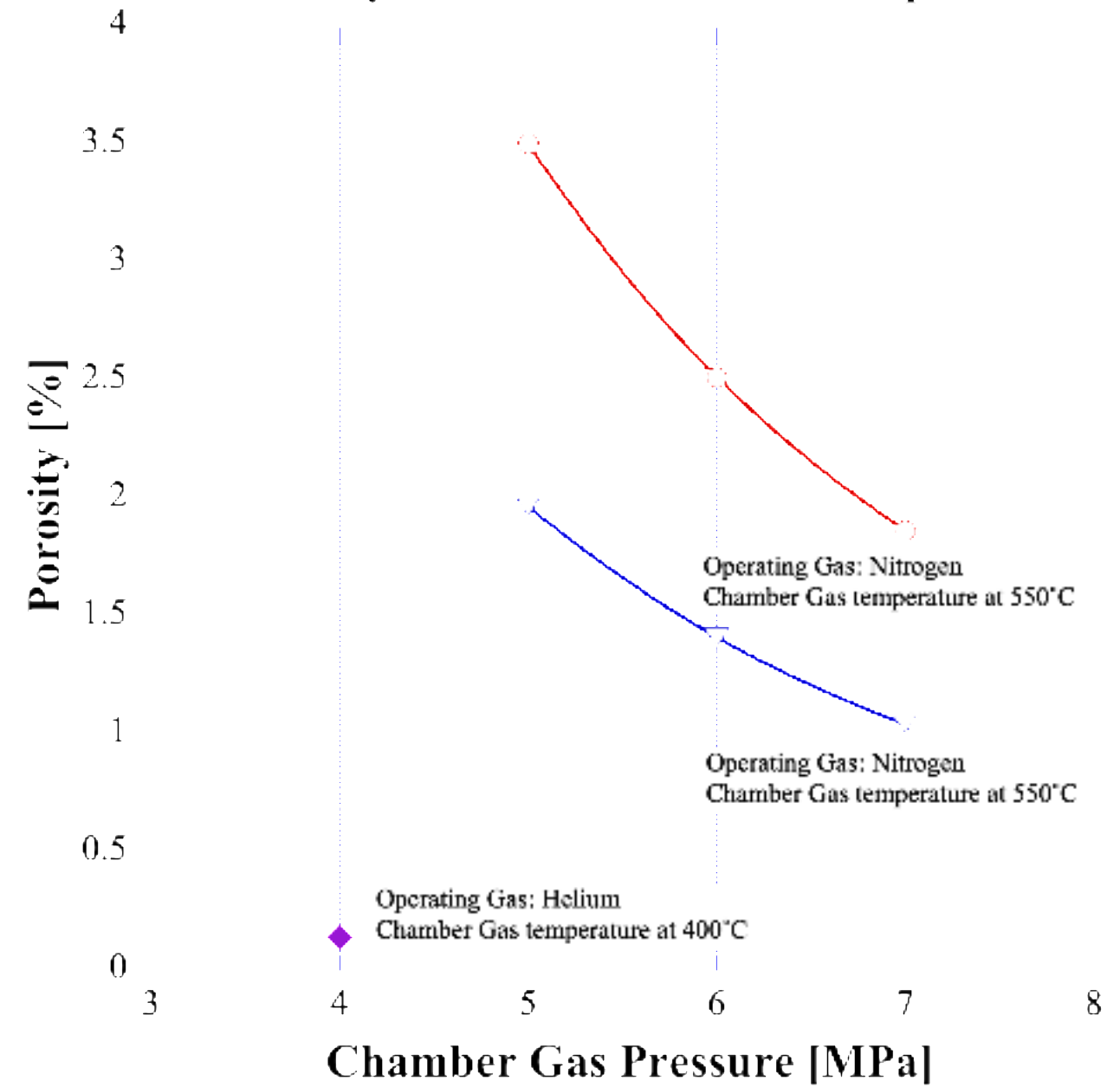
Gas	Chamber Gas Pressure	MPa	4	5	6	7
	Chamber Gas Temperature	°C	400	550		
He	Spray Material	A6061	○	—	—	—
N2	Spray Material	99.7% Al	—	○	○	○



Results



Porosity of Pure Al and A6061 Deposits



Results:

Deposition Efficiency vs. Gas Pressure

- Pure Al higher deposition efficiency than A6061 at the same nitrogen pressure and temperature.
- A6061 + He 400°C achieves the highest efficiency, even at lower pressure (4 MPa).
- A6061 + N₂ shows efficiency, rising slightly with pressure (5 to 7 MPa).

Porosity vs. Gas Pressure

- Pure Al + N₂ has lower porosity than A6061 under the same conditions. (~2.0% → ~1.0%).
- A6061 + N₂ shows higher porosity, but it decreases with increasing gas pressure (~3.5% → ~2.0%).
- A6061 + He 400°C has near-zero porosity (~0.1%), showing the best quality deposition.

Cross Section Photos

A6061 Deposit

**Helium Gas
400°C
4MPa**



**Helium Gas
400°C
4MPa**



99.7% Al Deposit

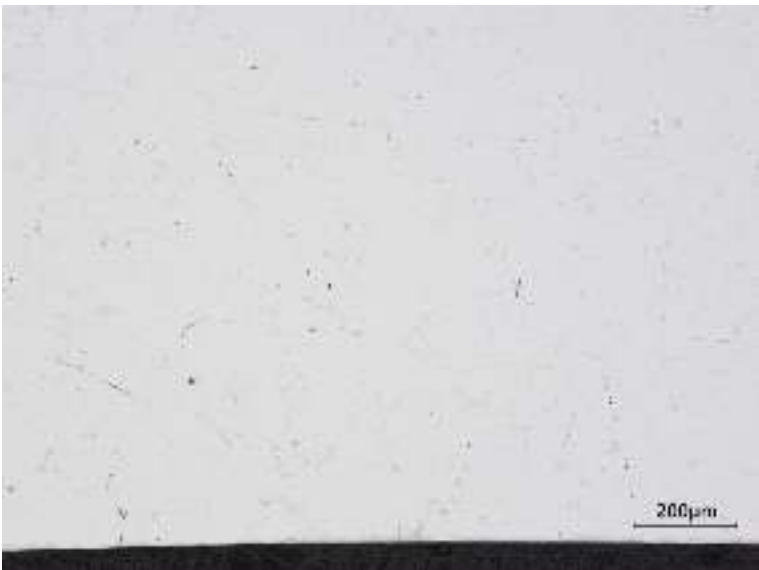
**Nitrogen Gas
550°C
7MPa**



**Nitrogen Gas
550°C
6MPa**



**Nitrogen Gas
550°C
5MPa**



Thank you

ありがとうございます