Translating Cold Spray Research into Industrial Success

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Translating Cold Spray Research into Industrial Success

What are we here for today?

1. Talk a little about **cold spray**

2. Talk about **Polycontrols**

3. Discuss **four challenges** that I have faced in industry that I didn’t see in academia

4. Discuss **two areas of research** that I think the community should focus on to best help the industry (with some examples)

J Therm Spray Tech (2023) 32:1864–1878
https://doi.org/10.1007/s11666-023-01611-4

PEER REVIEWED

Cold Spray: Everything Matters

D. MacDonald

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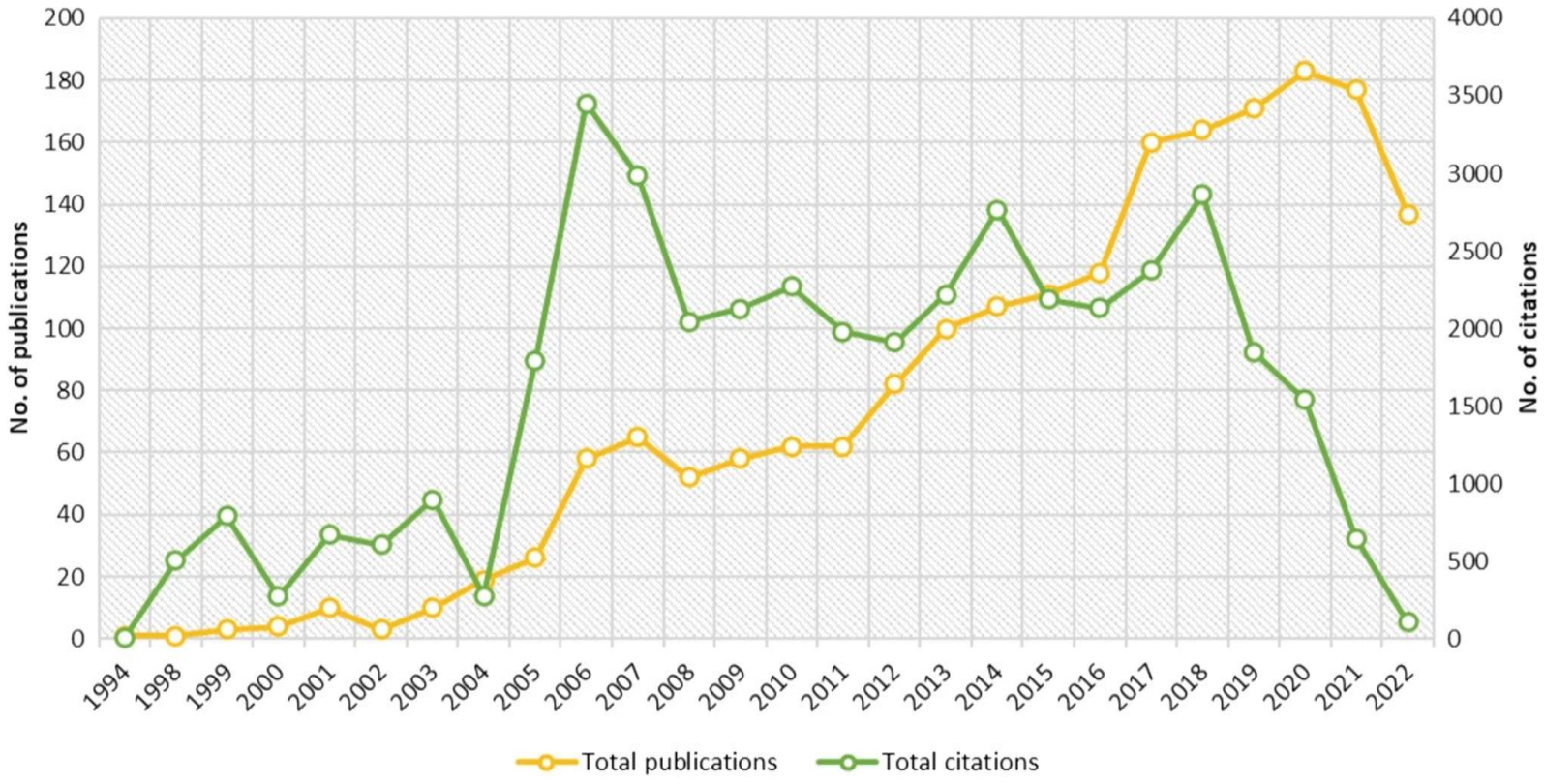
Abstract In high-pressure cold spray, it has been demonstrated that the enthalpy of the particle carrier gas has a significant effect on the propellant gas conditions and resulting particle impact velocities and temperatures. Through modeling and experimentation, this study demonstrates that in low-pressure cold spray, the enthalpy of the particle carrier gas has a minimal effect on the particle velocity; therefore, particle temperature can be controlled independently from particle velocity. This is a unique feature of downstream injection and a valuable tool when dealing with temperature sensitive substrates and particles. In this study, particle preheating was used to inject pure aluminum particles up to temperatures of 500 °C, about 80% of their melting temperature. This

Introduction

Cold spray (CS) is a solid-state thermal spray process which utilizes kinetic energy, as opposed to thermal energy, for particle deposition. In the CS process, particles are accelerated by a high speed gas flow prior to impact with a substrate (Ref 1, 2). During impact, the particles experience localized deformation, at rates much higher than those observed in traditional manufacturing processes, resulting in localized heating, material jetting, mechanical interlocking, metallic bonding, and ideally, permanent adhesion. The accumulation of these adhered particles results in the production of a new coating or component (Ref 1, 3-6). In CS, two approaches are used to insert

30 Years of Cold Spray Research

- **Over 2000** publications on cold spray
- **Global** research effort
- There is **no limit** for publication, dissertations, and conferences
- I love cold spray!



Abu Bakar, I.A., Omar, N.I., Yusuf, Y. et al. Reflection and Future Perspectives in Cold Spray Technology: A Bibliometric Analysis. J Therm Spray Tech 32, 1576–1595 (2023).

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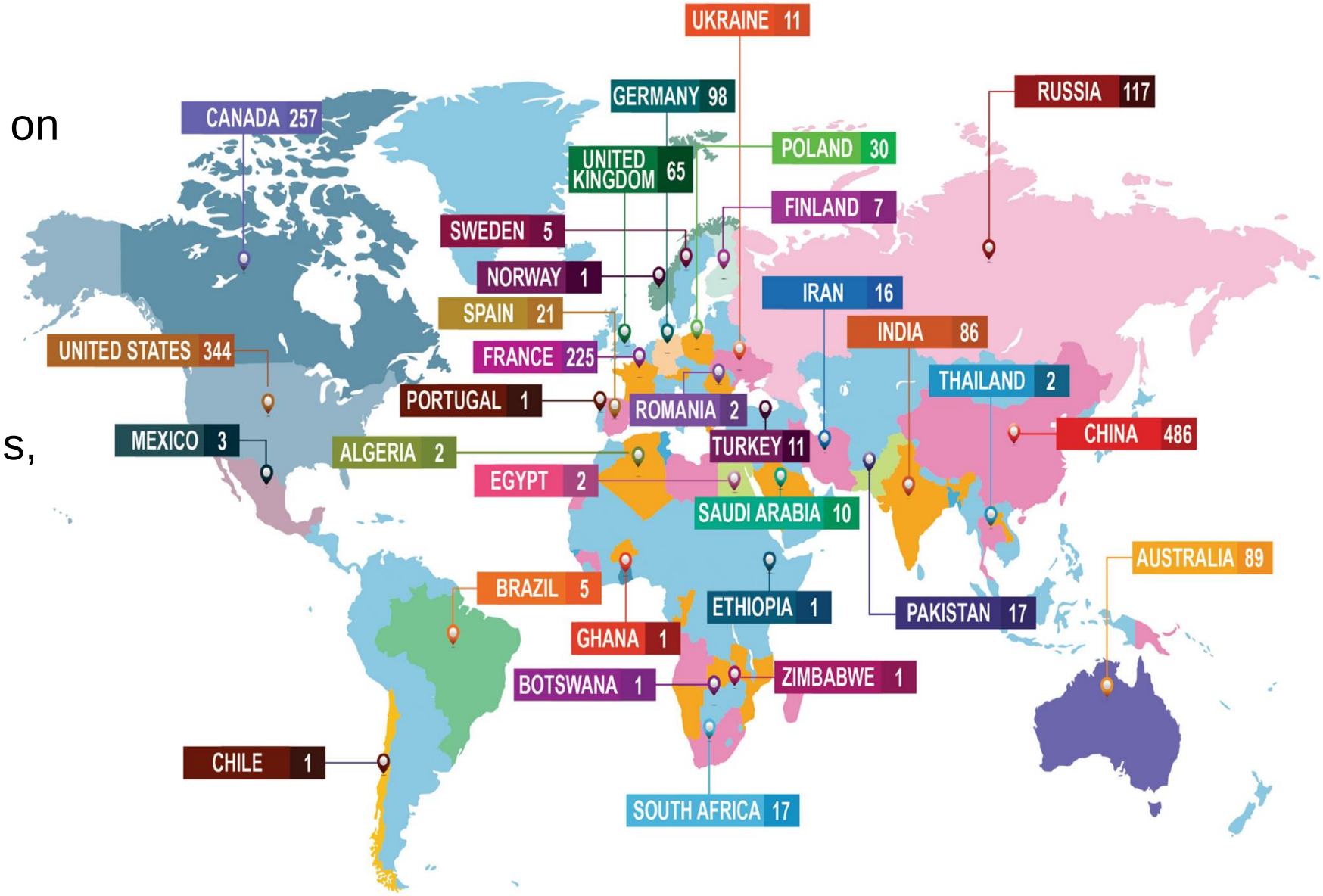

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Cold Spray is Not Simple

- The thing that made my time in academia so interesting is the very thing that makes my job in industry so difficult
- There is no “universal truth” in cold spray
- Each opportunity for cold spray requires R&D investment
- The science is always changing
- The materials are always evolving
- The equipment is always improving

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How Polycontrols Approaches this Challenge

- **Assemble a team** of materials science and cold spray experts
- Supported by a **full engineering team**
- Collaborate with the **National Research Council of Canada** (NRC)
- Stay up to date by **attending conferences** and reading the literature

Specific Challenges I have Faced in Industry and Not Academia

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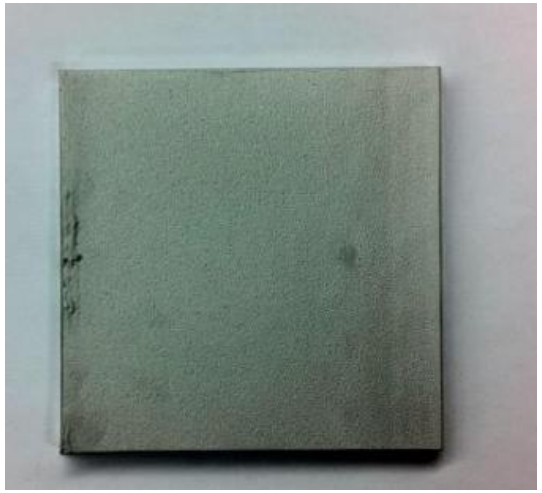
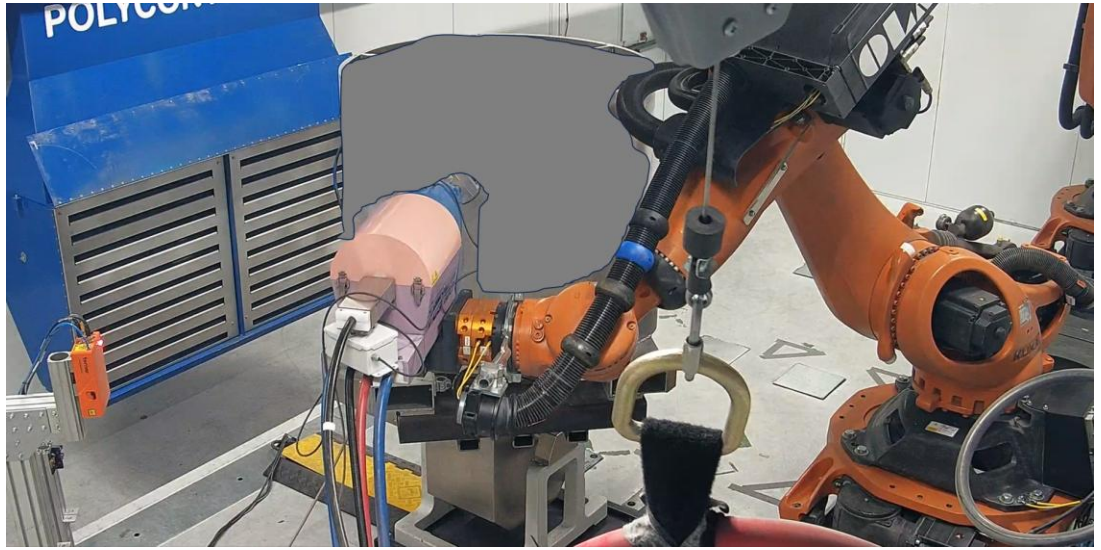
Scale

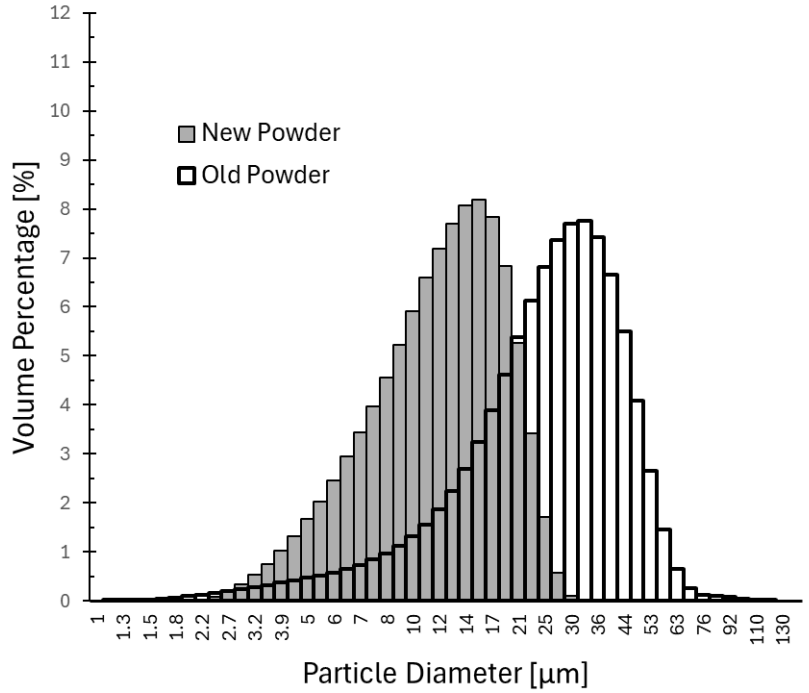
- The results on tiny samples **don’t always reflect reality on large parts**
- Different thermal history, traverse speeds, spray angles, standoff distances – **everything matters**
- Samples cannot be discarded as outliers when the parts take **days to spray!**





Powder Consistency

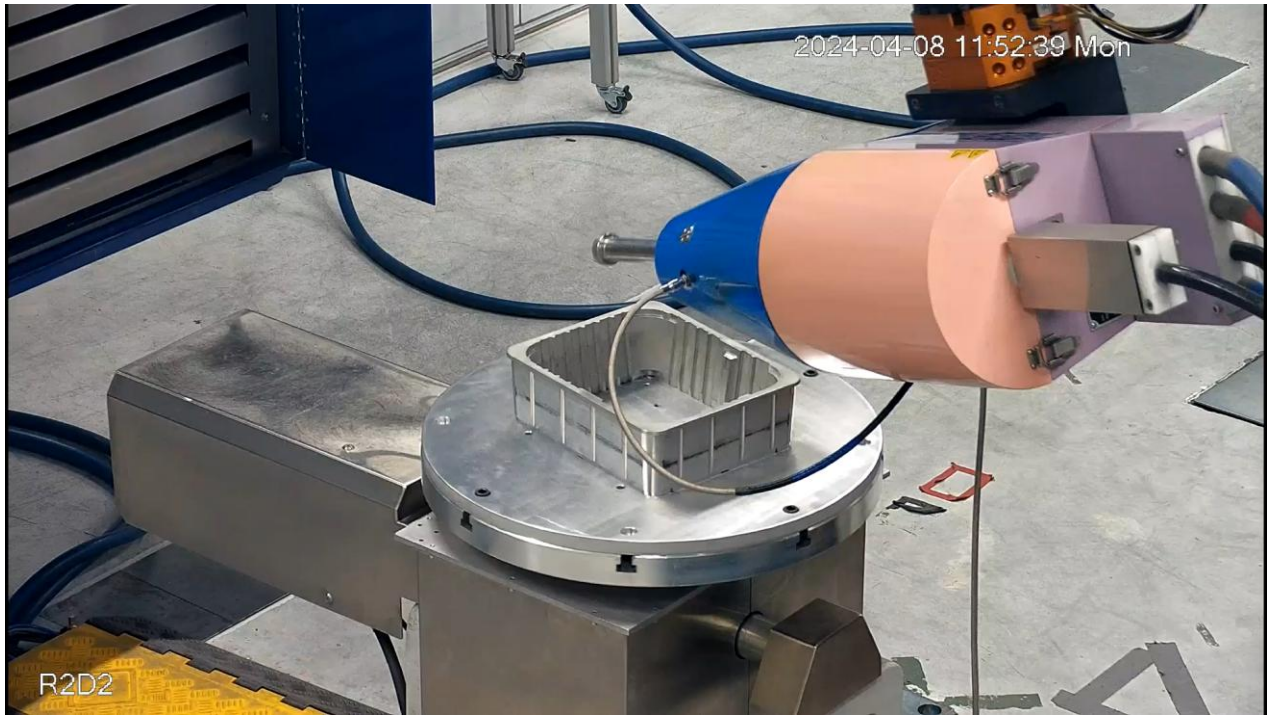
- A single publication can often be done with an individual batch of powder, usually **a single container**
- In the industry, we may need to purchase the same powder, **months or years apart**
- **Not always the same!** Different size distributions, oxygen content, natural aging, exposure to humidity, etc, will all influence the sprays... - **Everything Matters**



Robotics

- Simple X-Y raster is not appropriate for all parts

- Often complex gun movement is required, which requires complex robot programming and coordination of multiple robots and turn tables (thank you to the engineering team)



Stopping before it’s Over

- Comprehensive studies are difficult in the industry
- Work is stopped when we have the answer that we need for the client and application; not necessarily when the science is fully understood
- I see fascinating problems to solve every day, but dedicating resources to exploring these things isn’t always necessary or in the company's interest
- If you are every looking for ideas or inspiration for industry relevant thesis topics, come and see me!

Focus for Research to Best Help Industry

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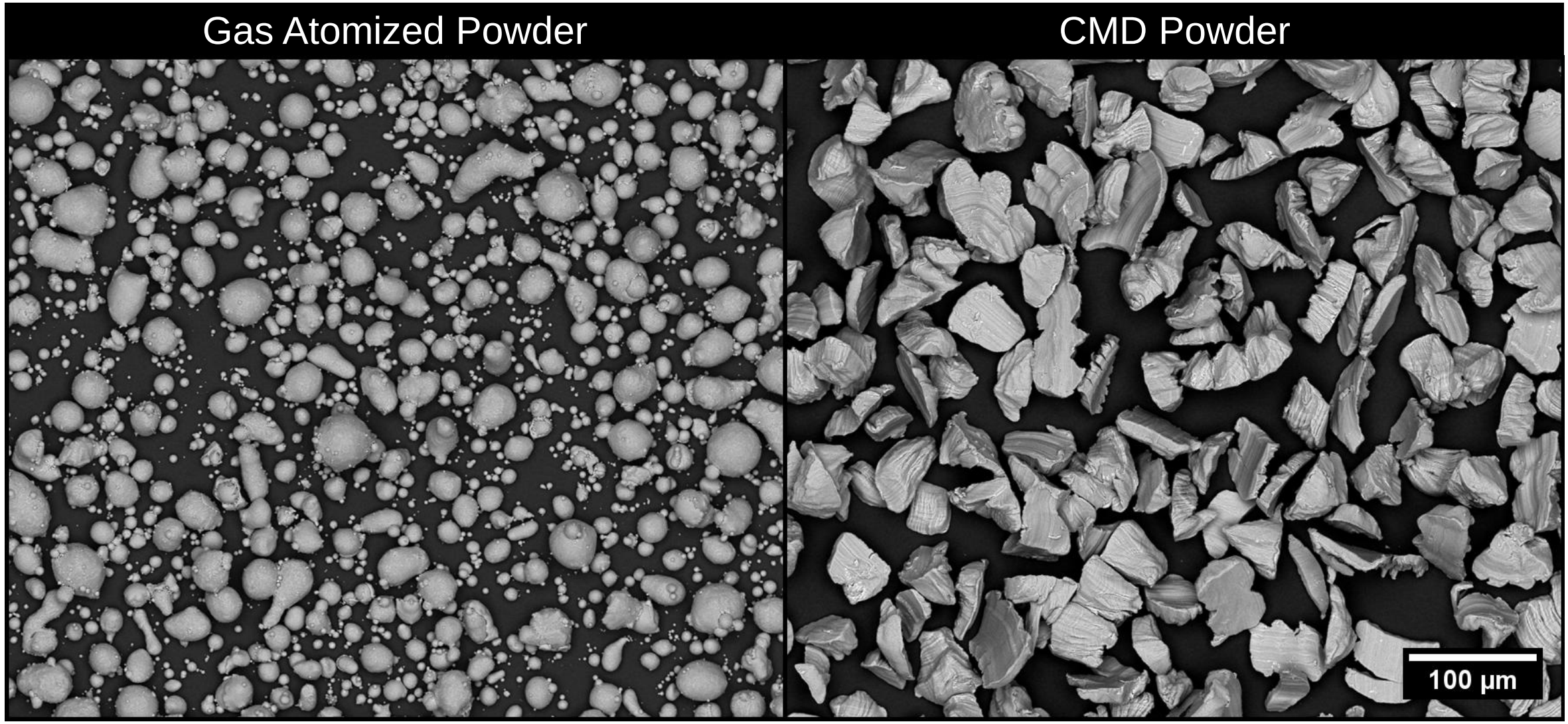
Focus on the Start

- **Powder will influence everything**
- Chemistry, heat treatment, morphology, production method, oxidation… **Everything matters**
- Focus research on new **powders specifically for cold spray**

The Influence of Powder



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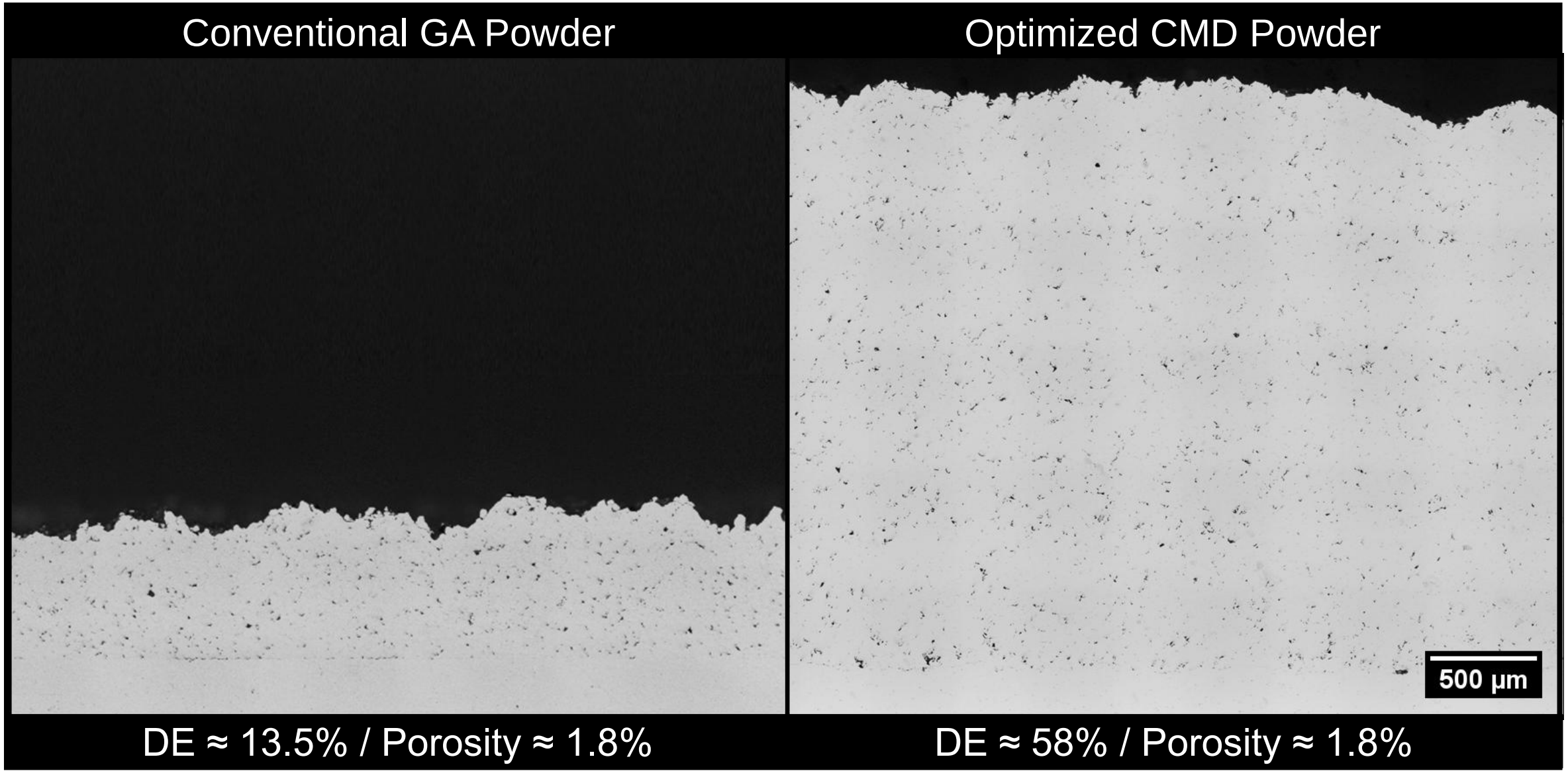
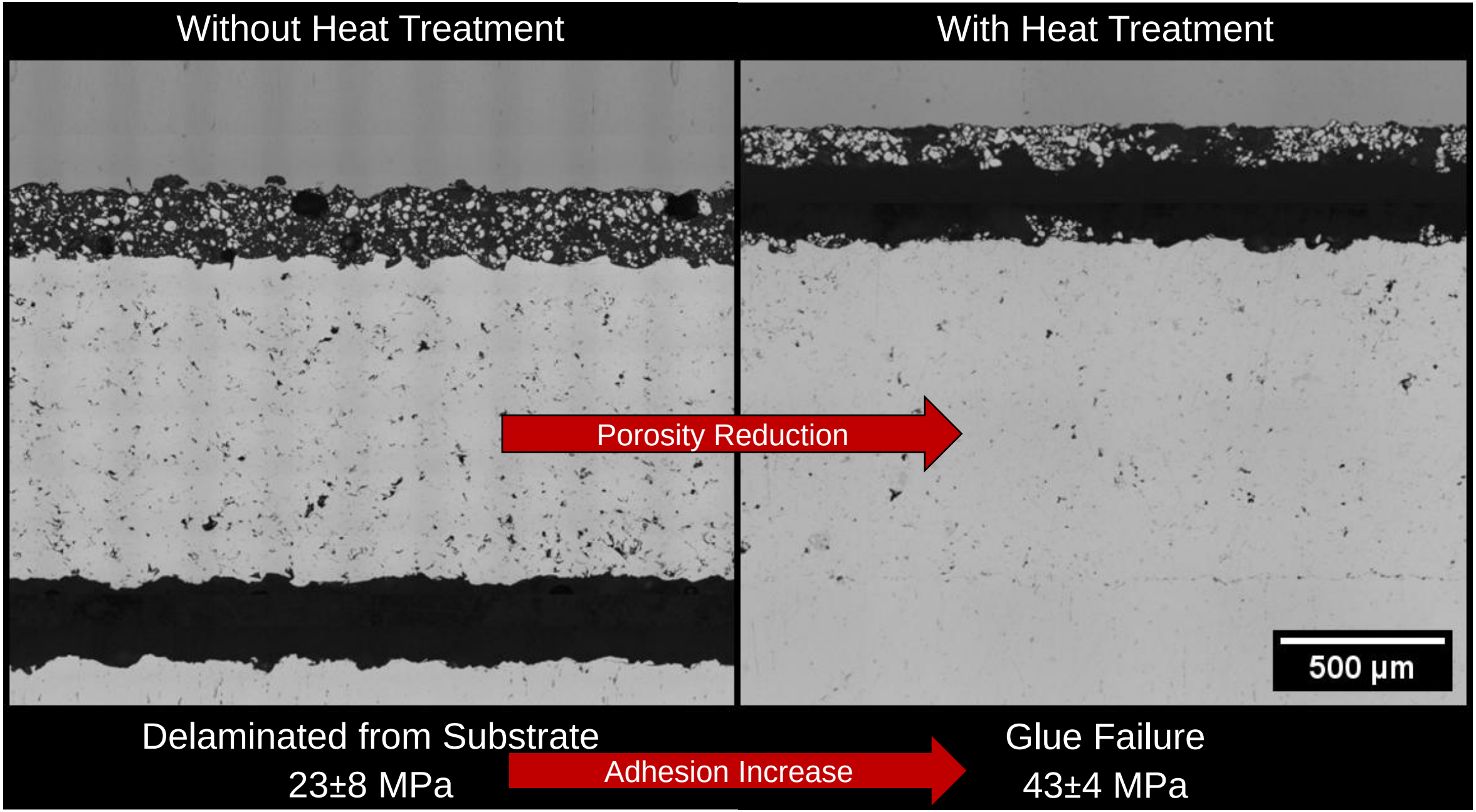


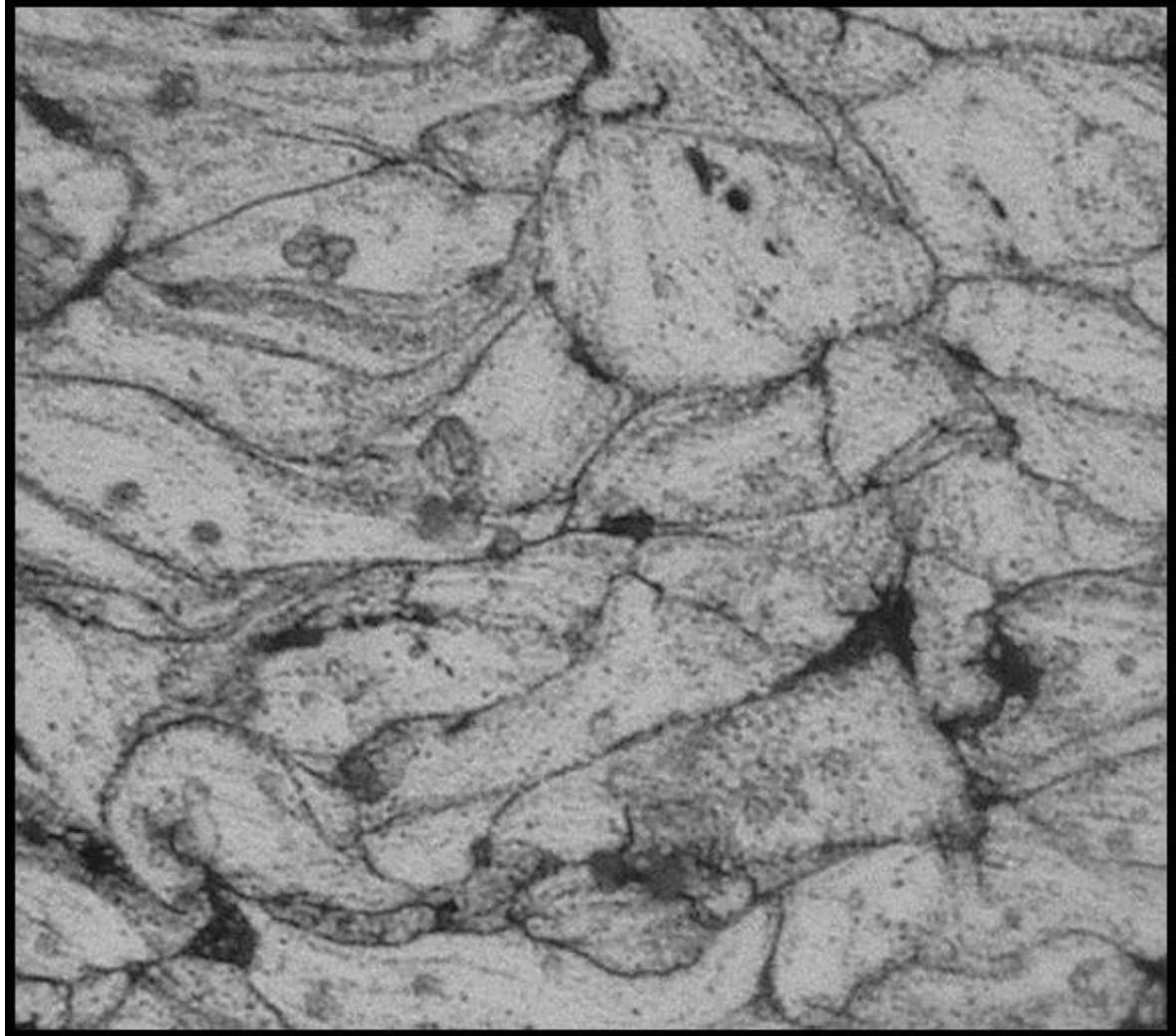
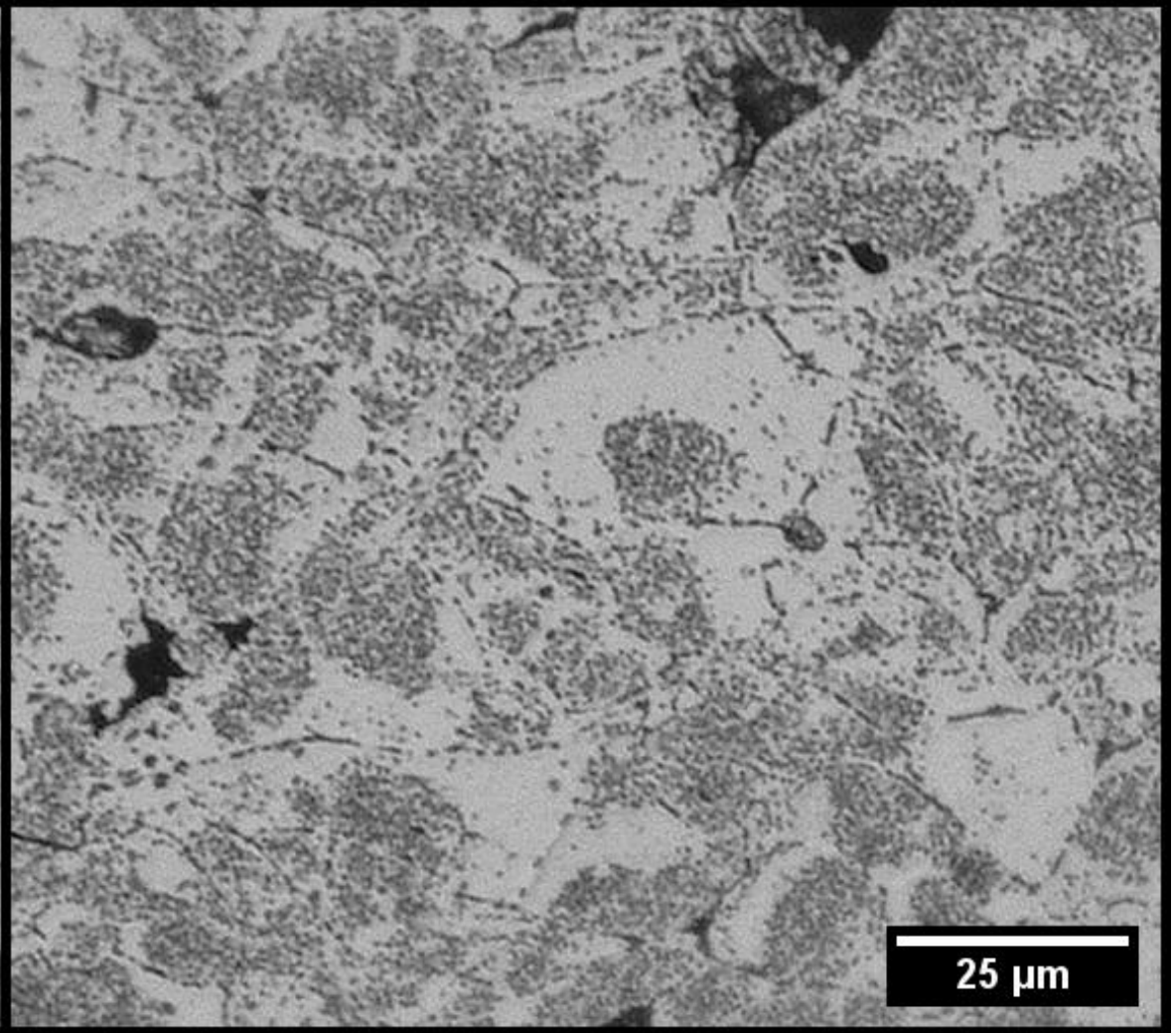
Focus on the End

- Increasing DE is great! Low porosity is amazing.
- But what about the mechanical properties…
- What about **heat treatment**?
- What about **cold spray specific** heat treatments?

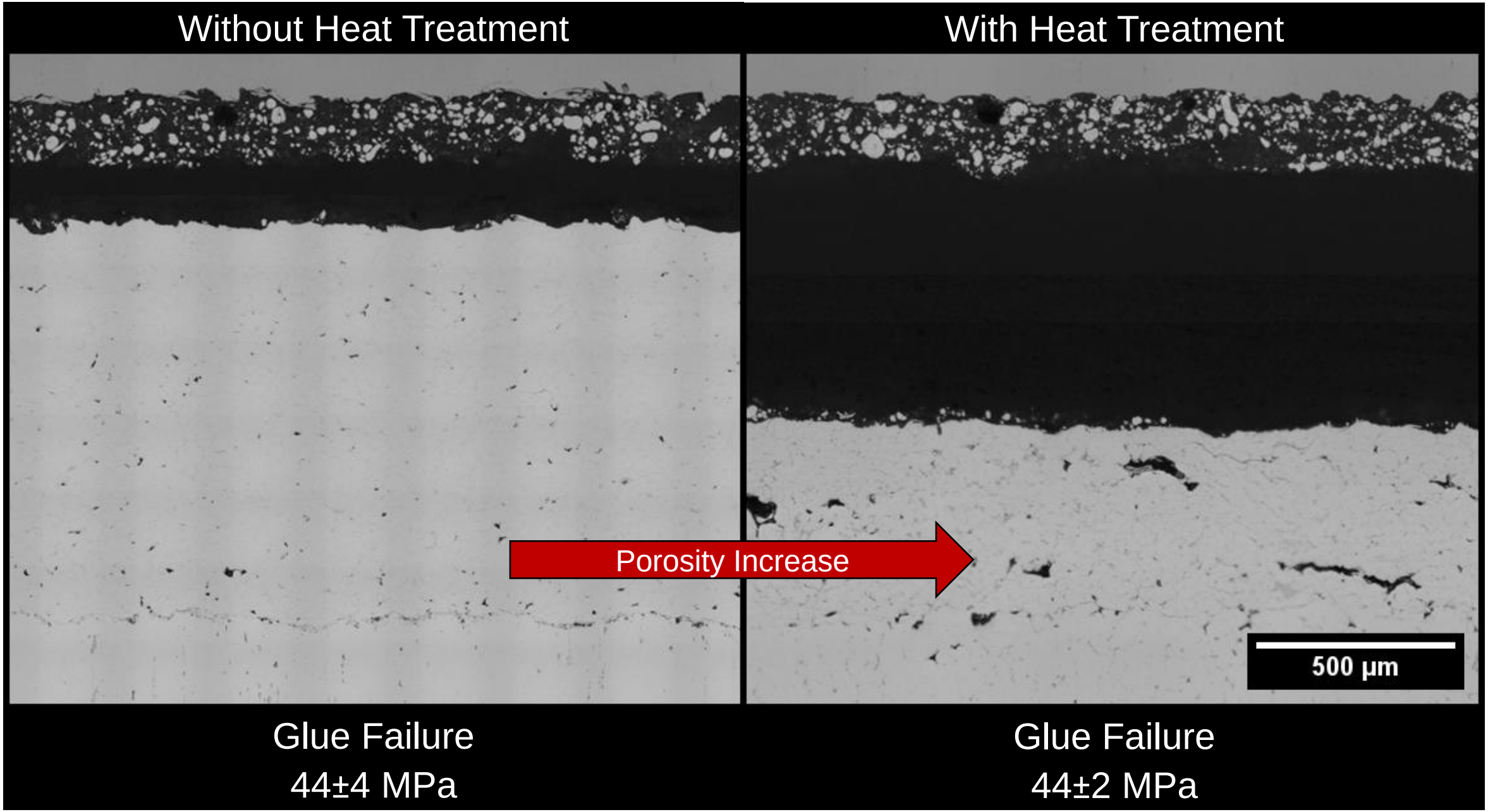
CMD: After ASTM C-633 Adhesion Testing



CMD: Etched Sample / Hardness

Without Heat Treatment	With Heat Treatment
	
Clear Particle Boundaries 110 ± 10 HV_{300g}	Less Pronounced Boundaries 94 ± 8 HV_{300g}

Gas Atomized: After ASTM C-633 Adhesion Testing



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	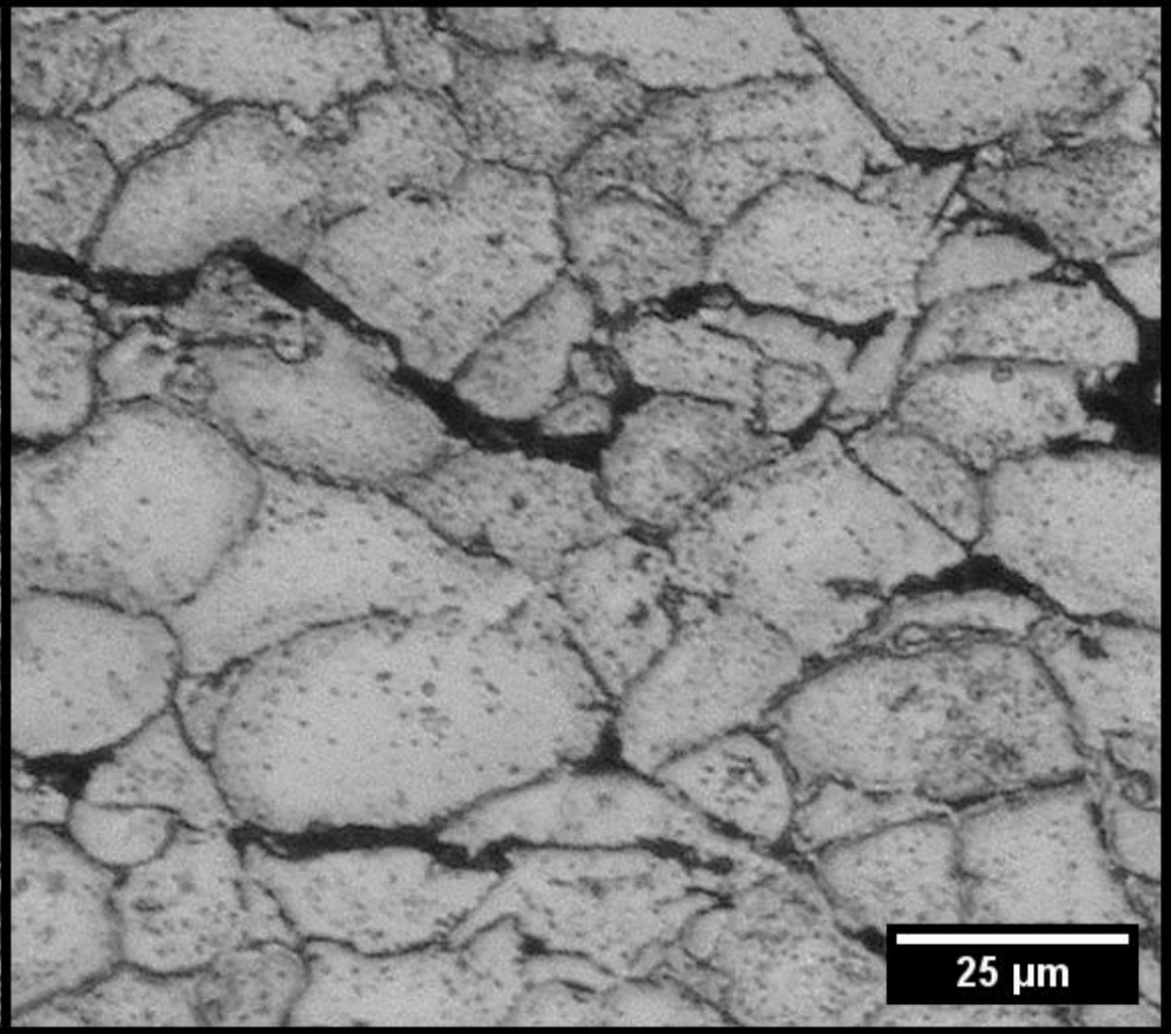
Grain Boundaries Prevalent	Particle Boundaries Prevalent
120 ± 5 HV_{300g}	132 ± 5 HV_{300g}

Conclusions

- Cold Spray is **NOT SIMPLE – Everything Matters**
- The industry needs continued research – **publishing and participation in conferences is essential**
- Focus on **the start** (the powder) and **the end** (the heat treatment) and how the start might influence the end

Thank you – Danke

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