Development of Metal Powder for A.M. Applications

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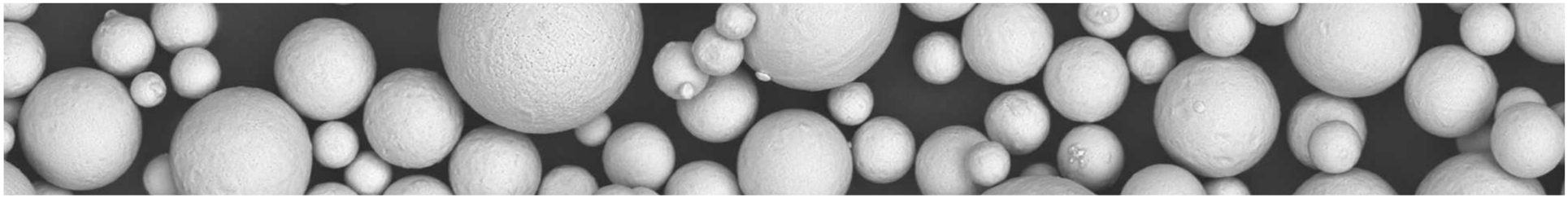
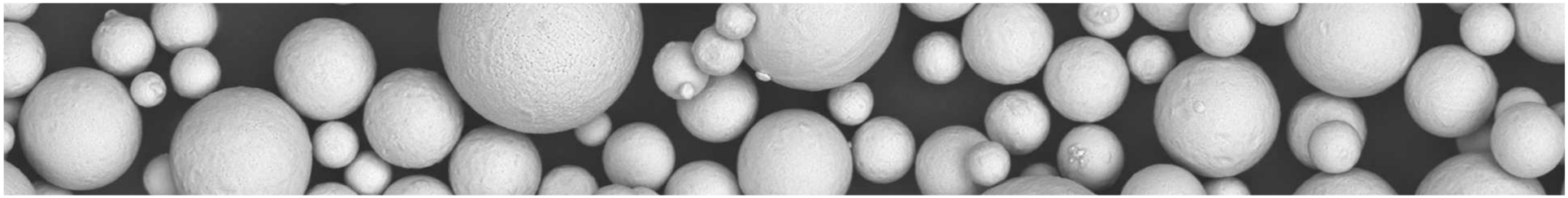
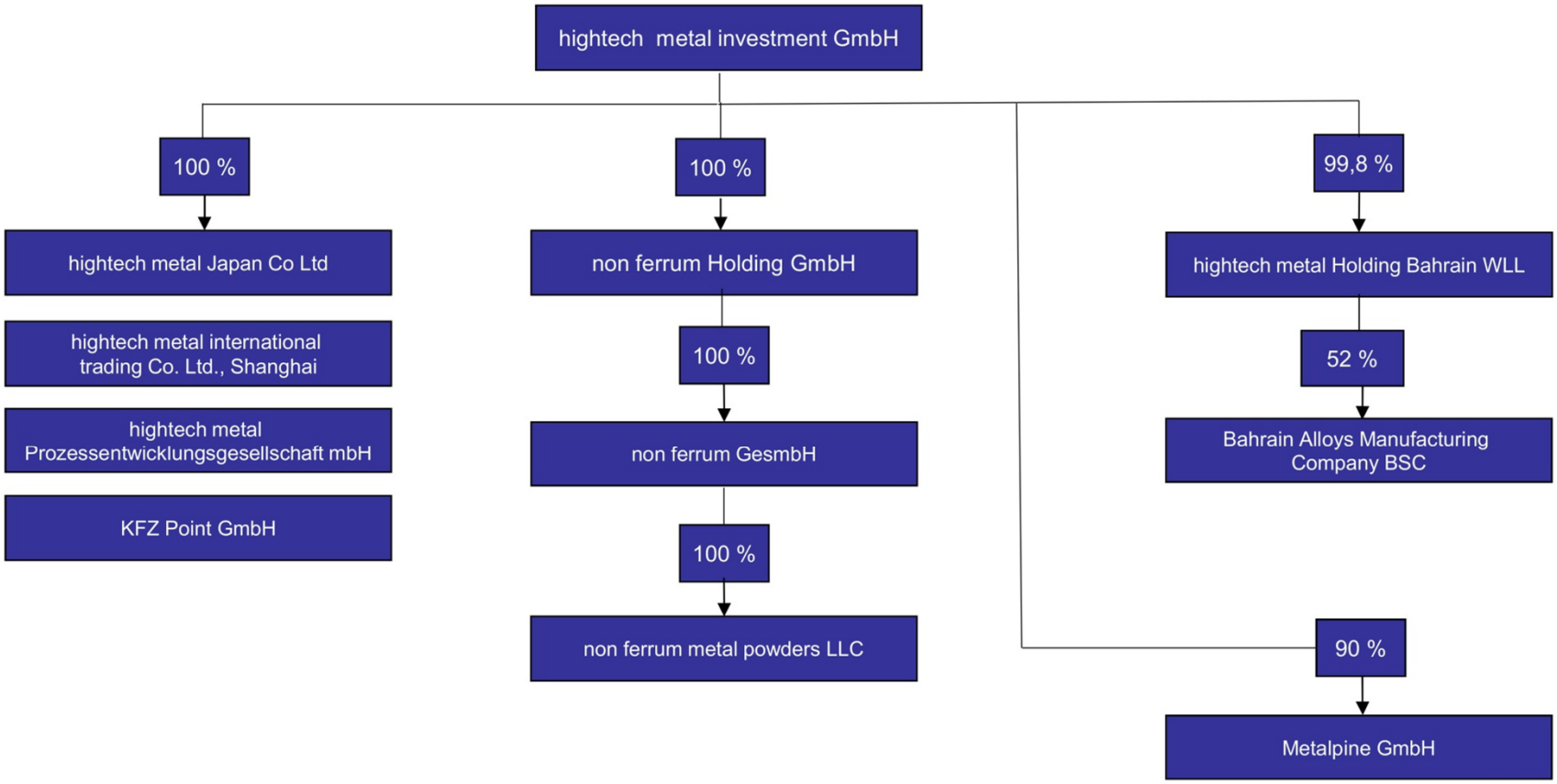
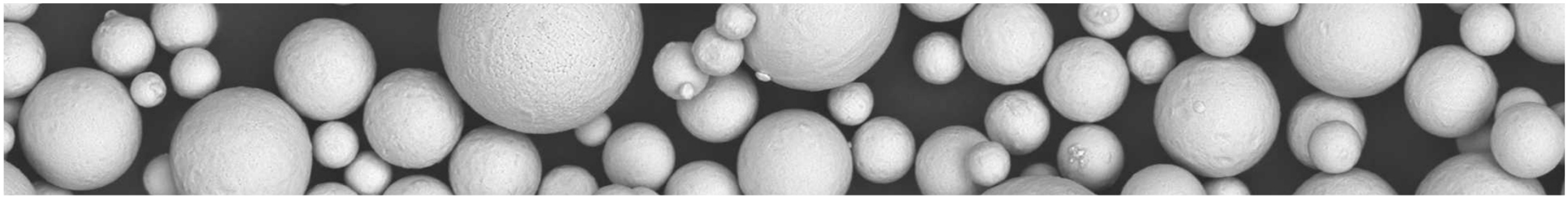


1. Introduction
2. Gas Atomization
3. Requirements on Metal Powders for AM Applications
4. Conclusions / Solutions



hightech metal Group – Company Structure as of 2019-03-31





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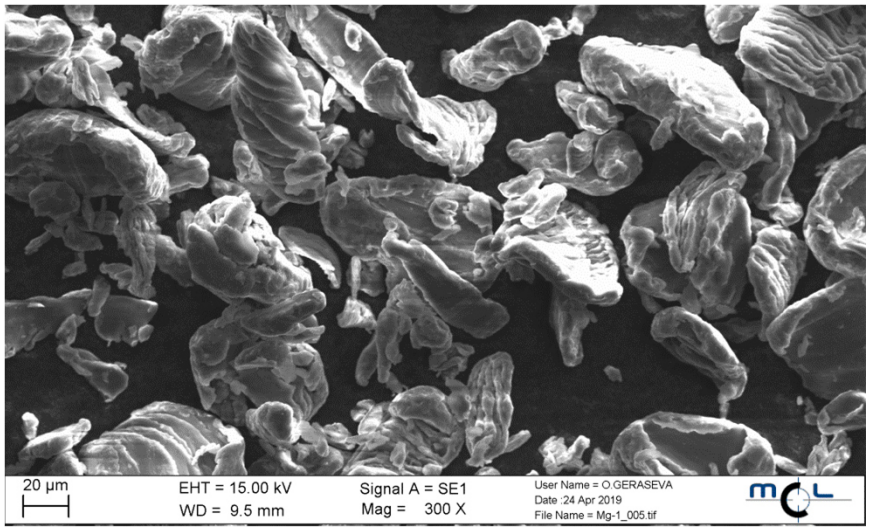
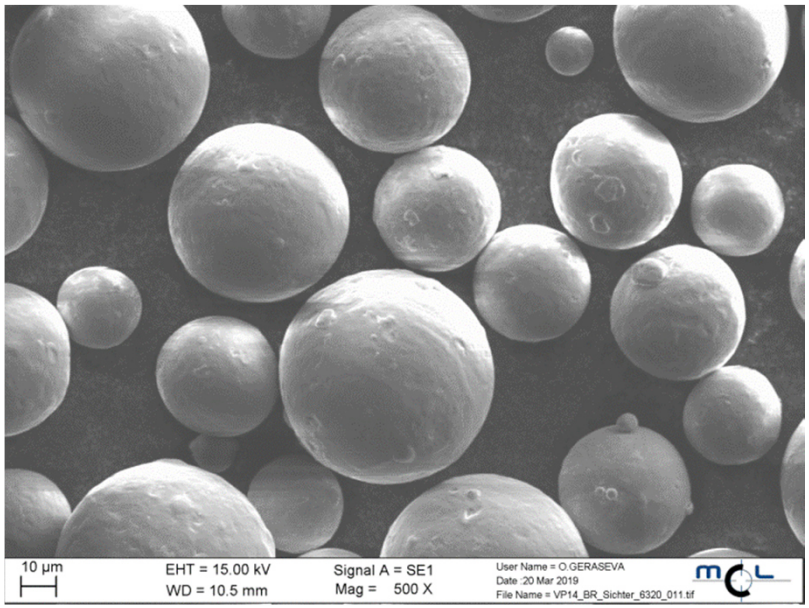
Metal Powder Production Processes

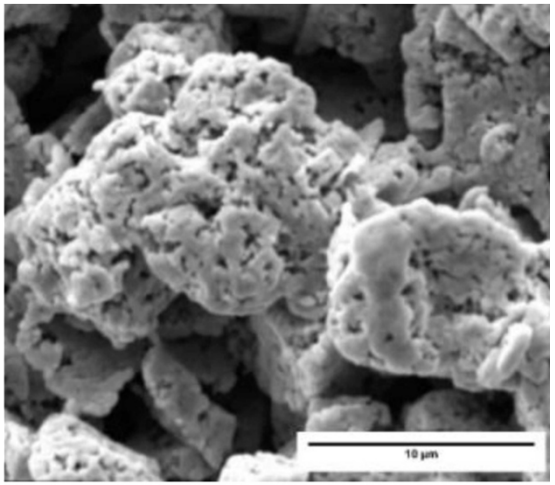
Grinding: Irregular Powders



Inert Gas Atomization: Spherical Powders



Direct Reduction: „Spongy“ Powders



[A study of the impact of reduction conditions on molybdenum morphology, 19th Plansee Seminar]

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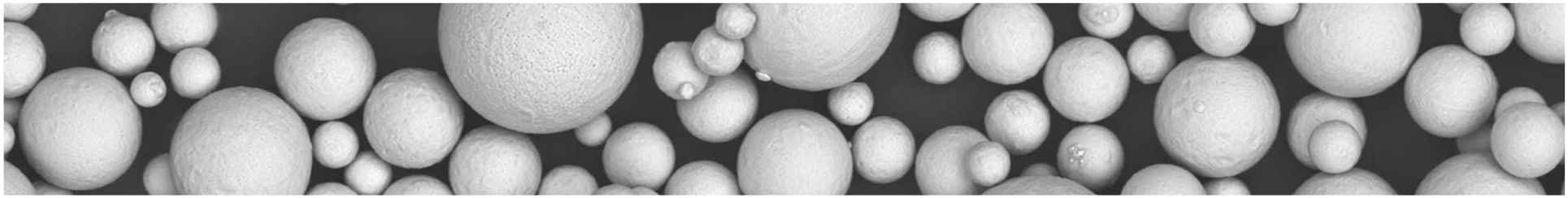
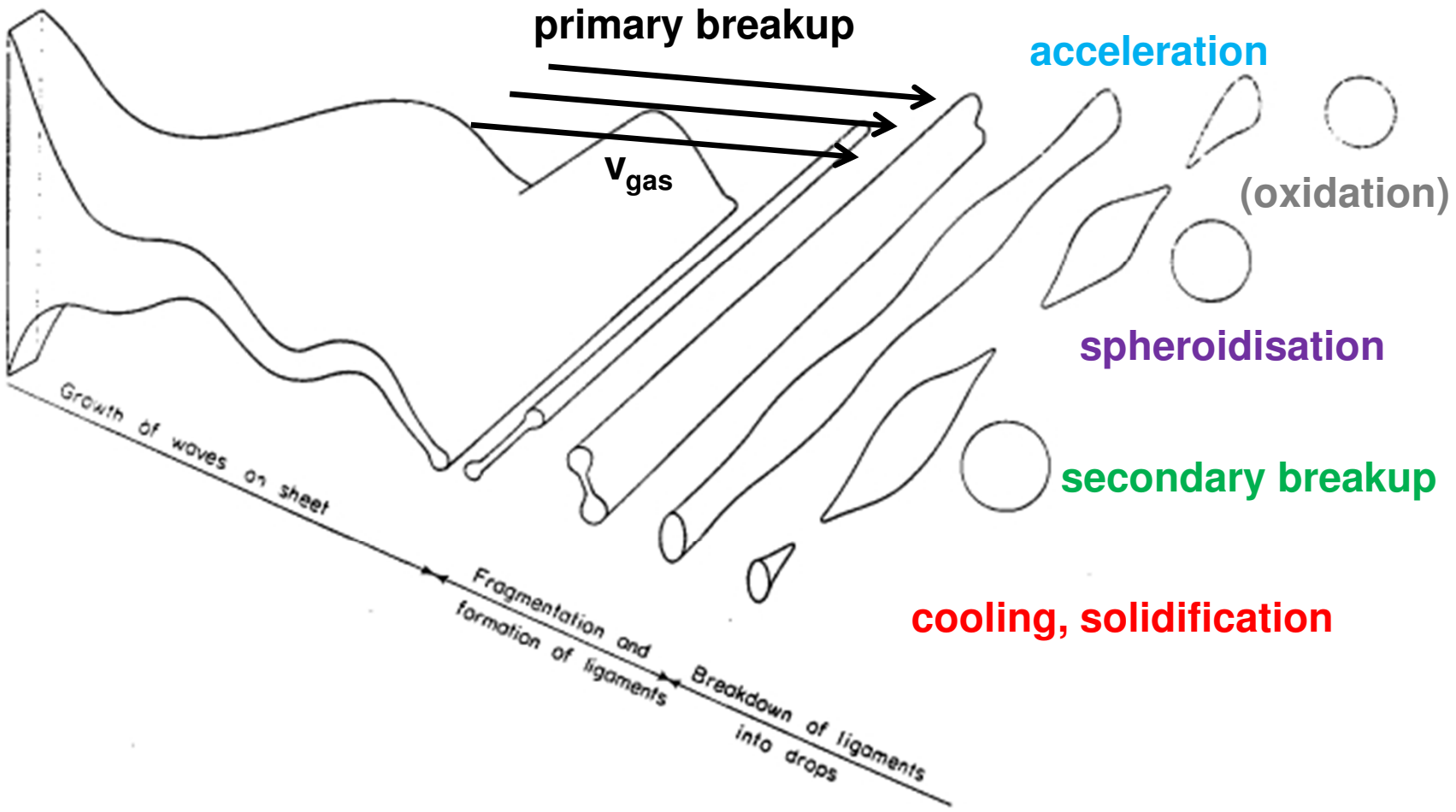
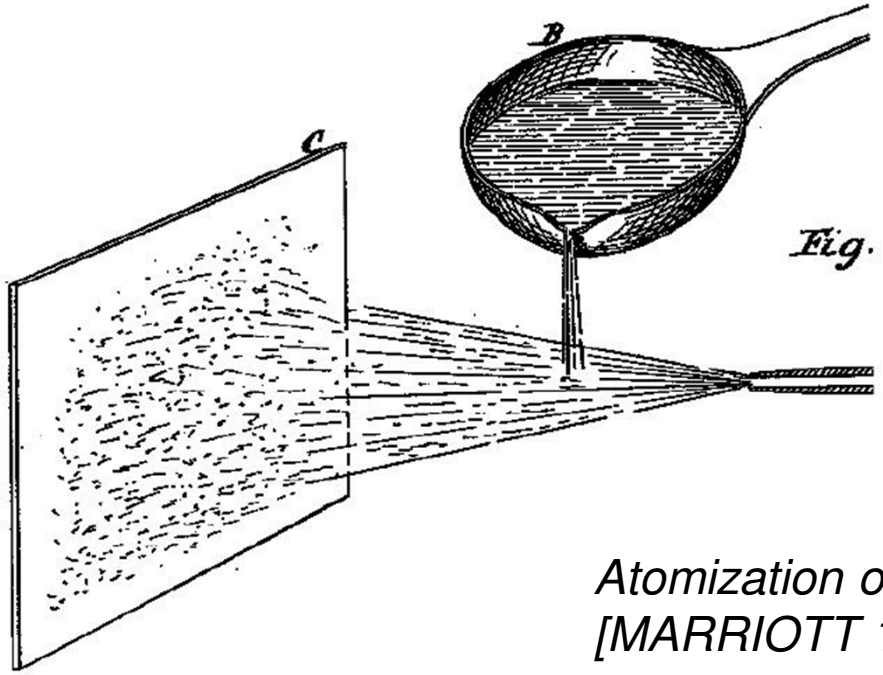
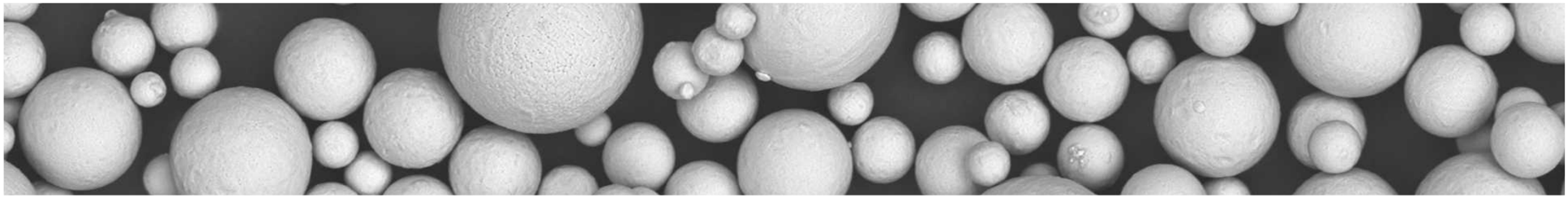


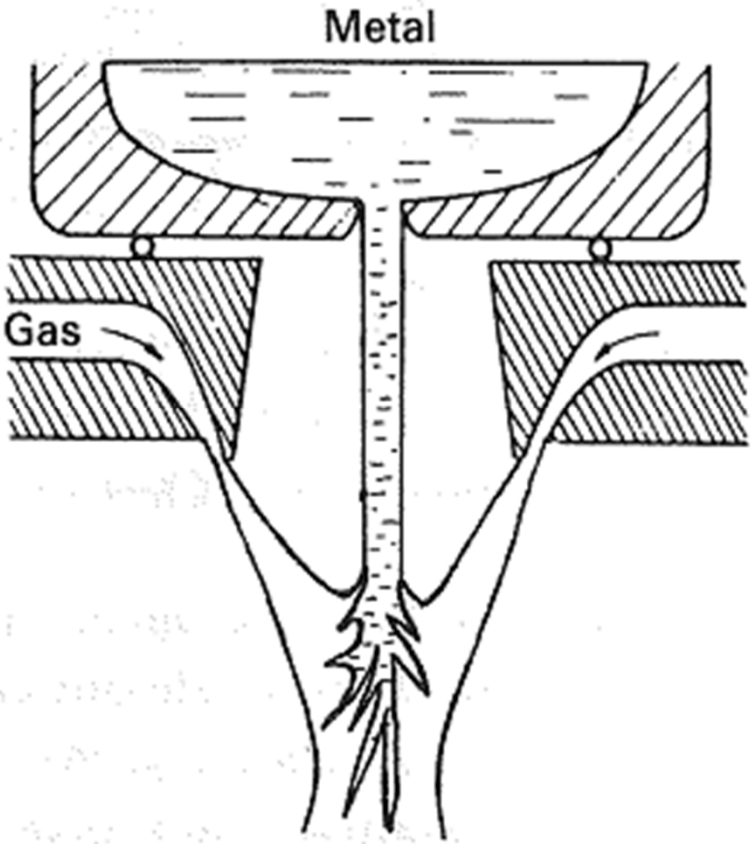

primary breakup
acceleration
v_{gas}
(oxidation)
spheroidisation
secondary breakup
cooling, solidification
Growth of waves on sheet
Fragmentation and formation of ligaments
Breakdown of ligaments into drops



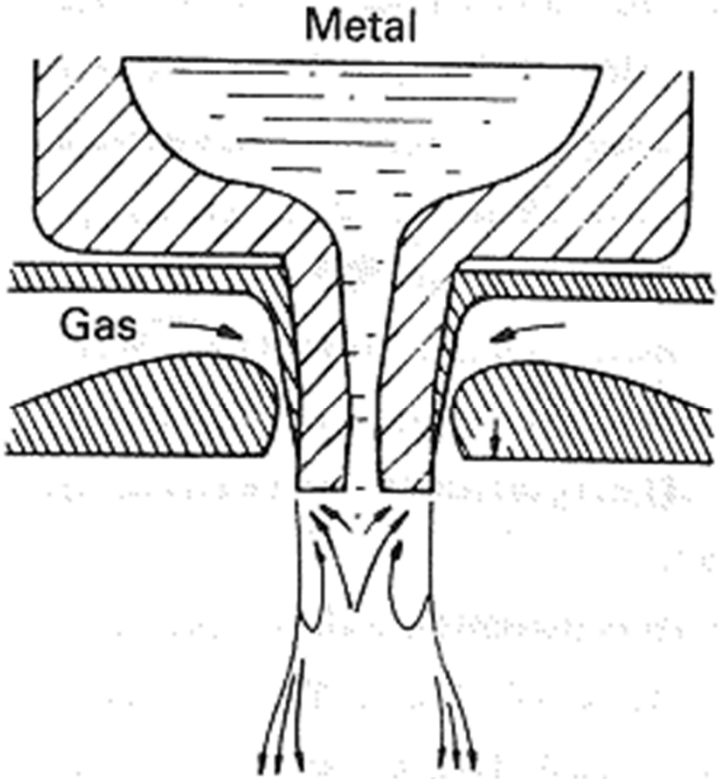
Atomization of Liquid Lead with Steam [MARRIOTT 1886]

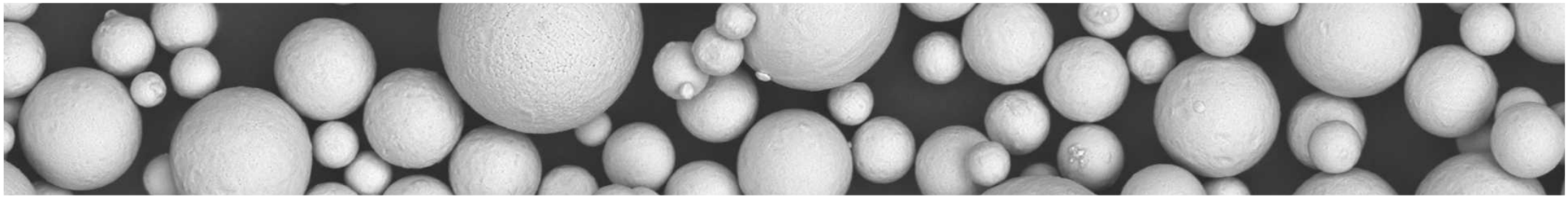


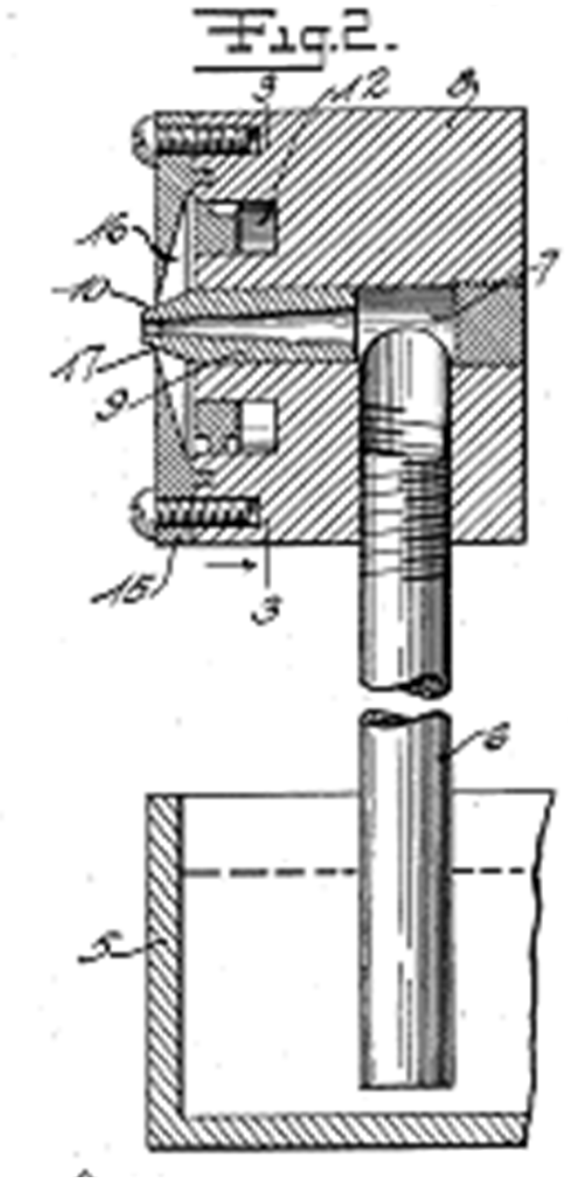
„Free Jet“



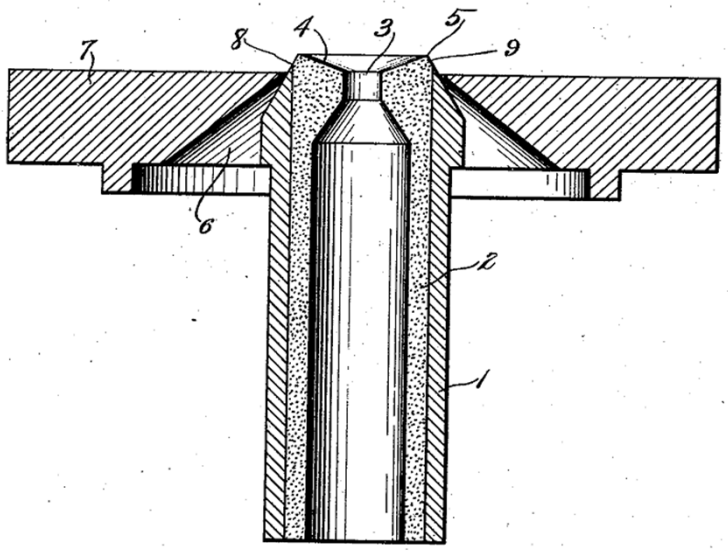
„Closed Couple“

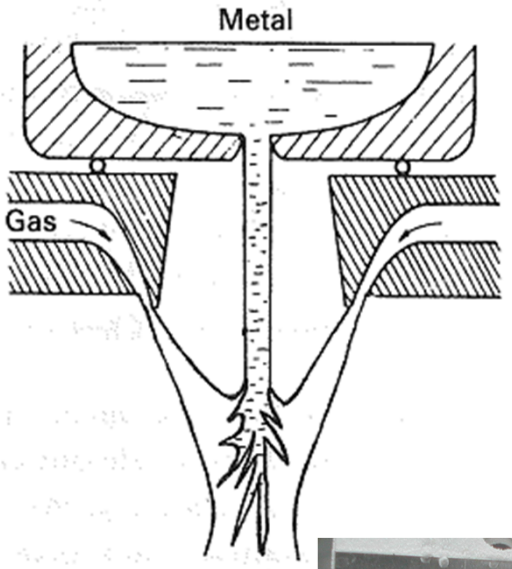


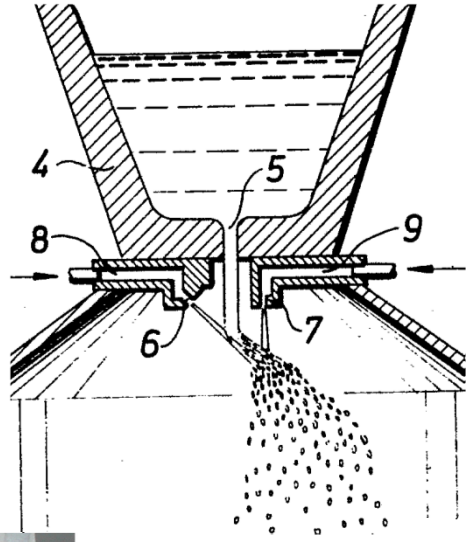




Hall (1917, 1919)



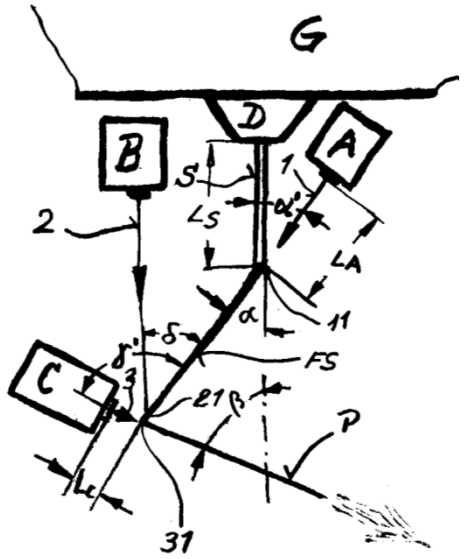




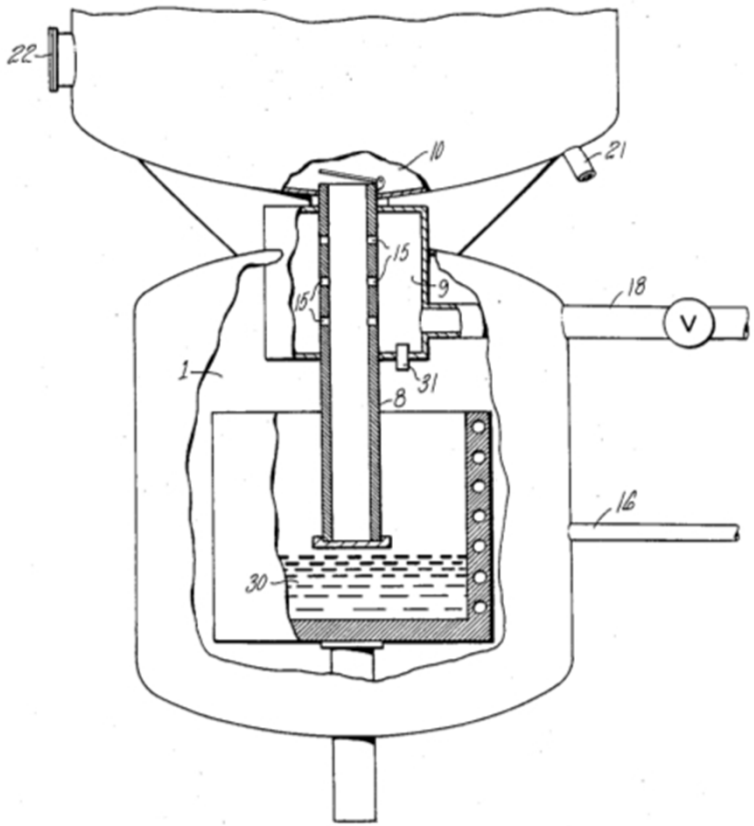
Hellmann (1970)

Steindl (2004)

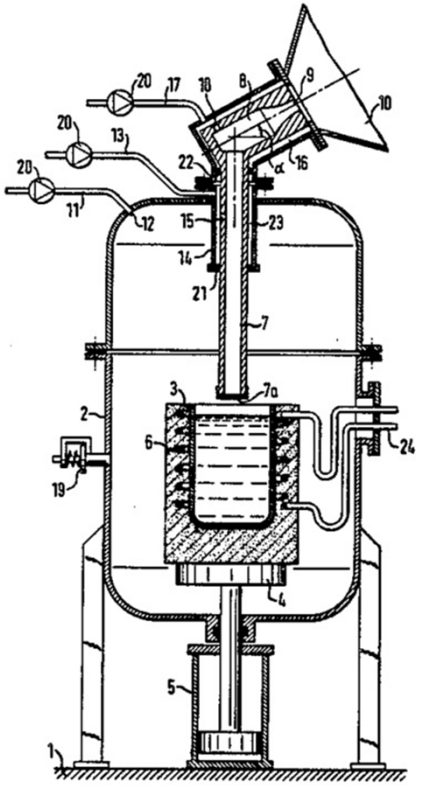
Tornberg (2000)



Internal mixing atomization:

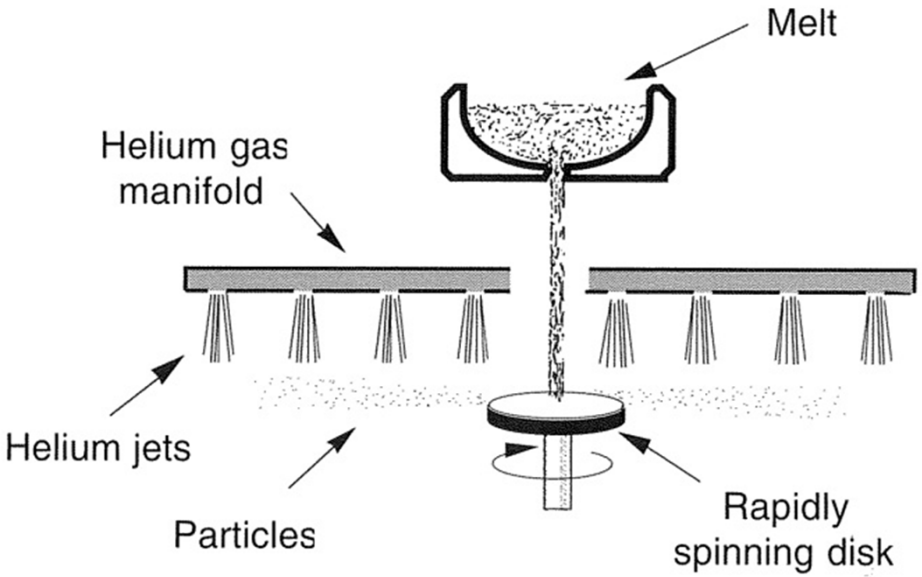


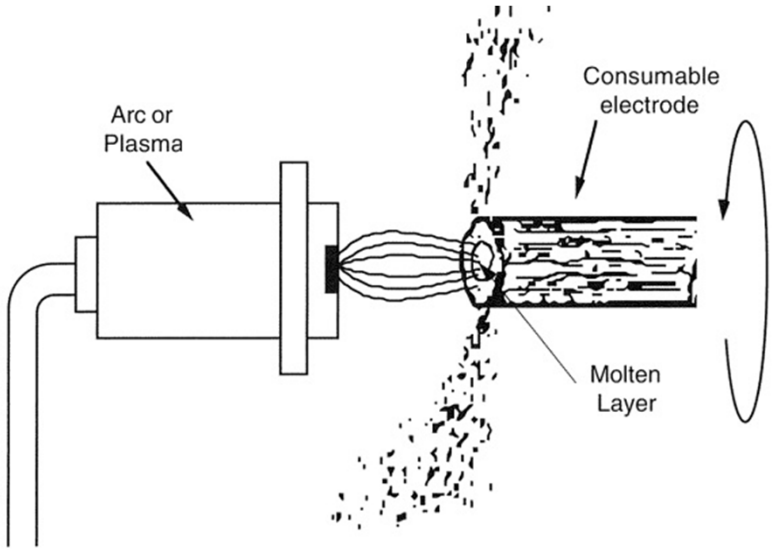
Basczcuk (1989)

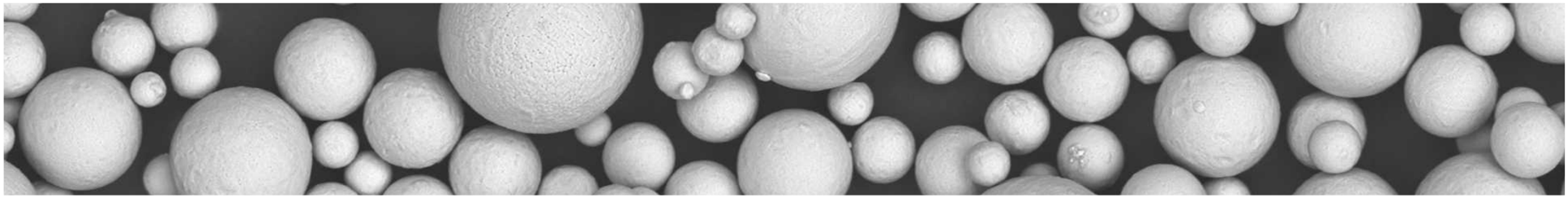


Wentzell (1984)

Development of Metal Powder for A.M. Applications
2. Gas Atomization







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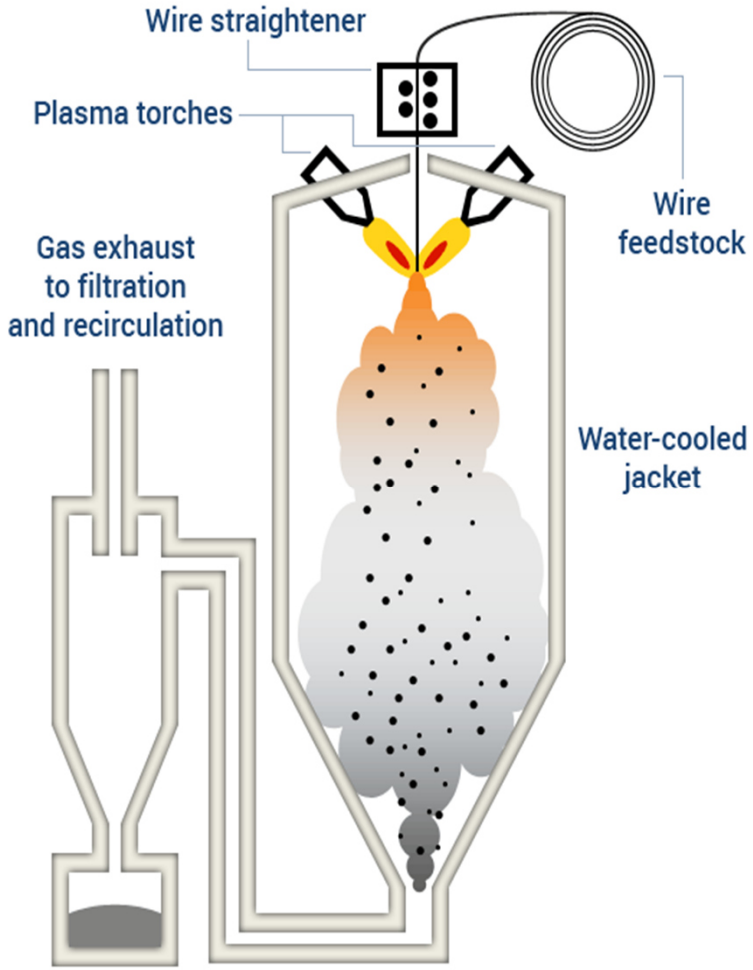
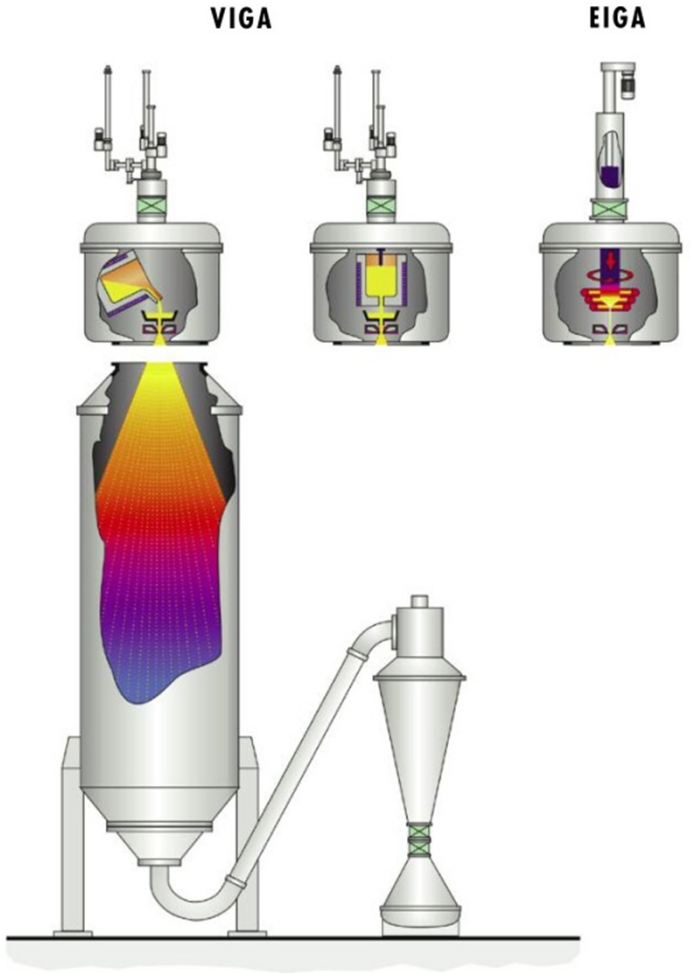


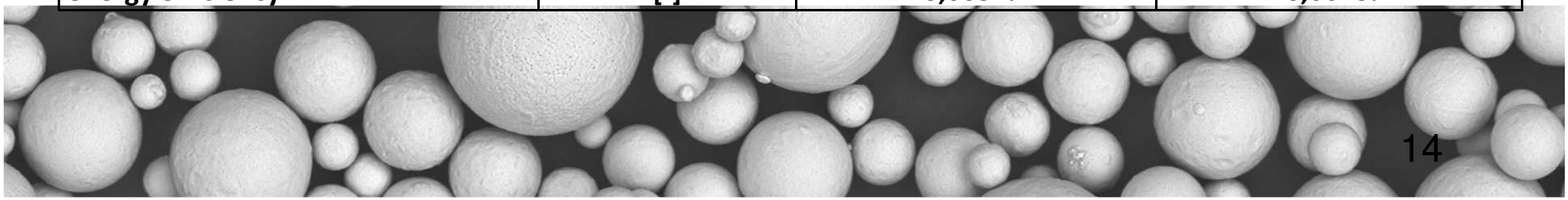
ALD



Energy efficiency of Gas Atomization Processes:

$$\eta_{atomization} = \frac{e_{powder}}{e_{atomization}} = \frac{\sigma S_m}{e_{gas} + \Delta h_{gas} + \Delta h_{melt}}$$

metal melt		**aluminium**	**steel**
melt superheat	[°C]	215	215
atomization gas temperature	[°C]	20	400
atomization gas pressure	[bar]	16,6	10
GLR (gas to liquid ratio)	[-]	8,49	1,10
specific surface area	[m²/kg]	200	20
surface tension	[N/m]	0,9	1,87
surface energy	[kJ/kg]	0,18	0,0374
gas compression energy	[kJ/kg]	236	194
gas heating energy	[kJ/kg]	0	382
melting energy	[kJ/kg]	1342	1013
total energy	[J/kg]	3349	1647
energy efficiency	**[-]**	**0,0054%**	**0,0023%**



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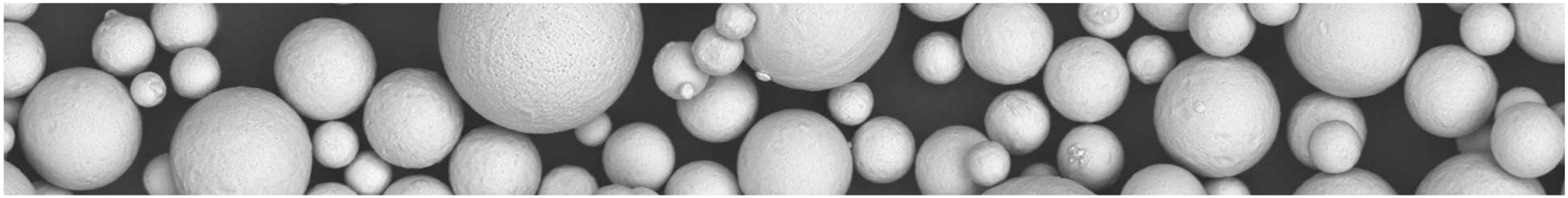

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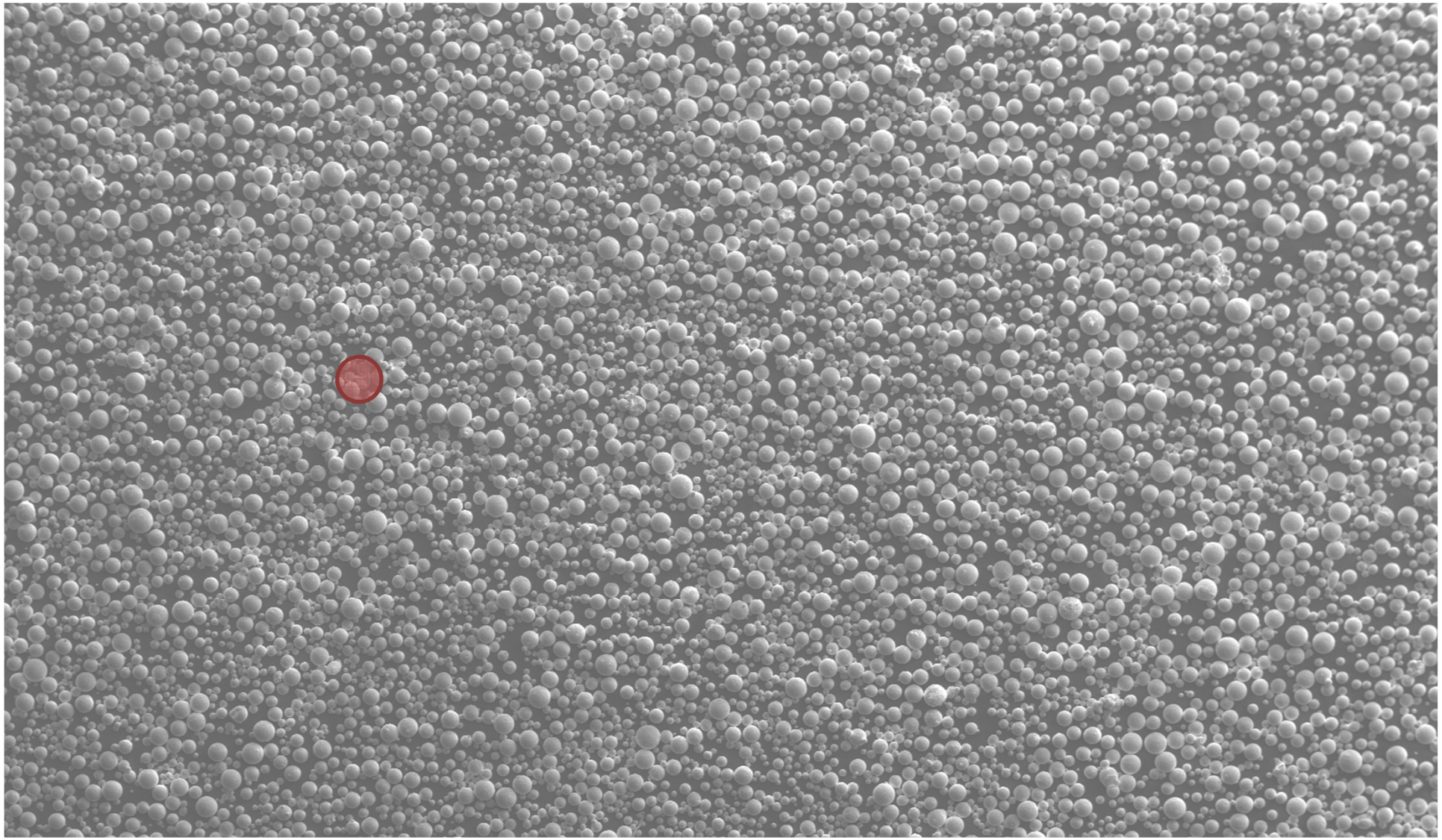
Powder Bed Fusion

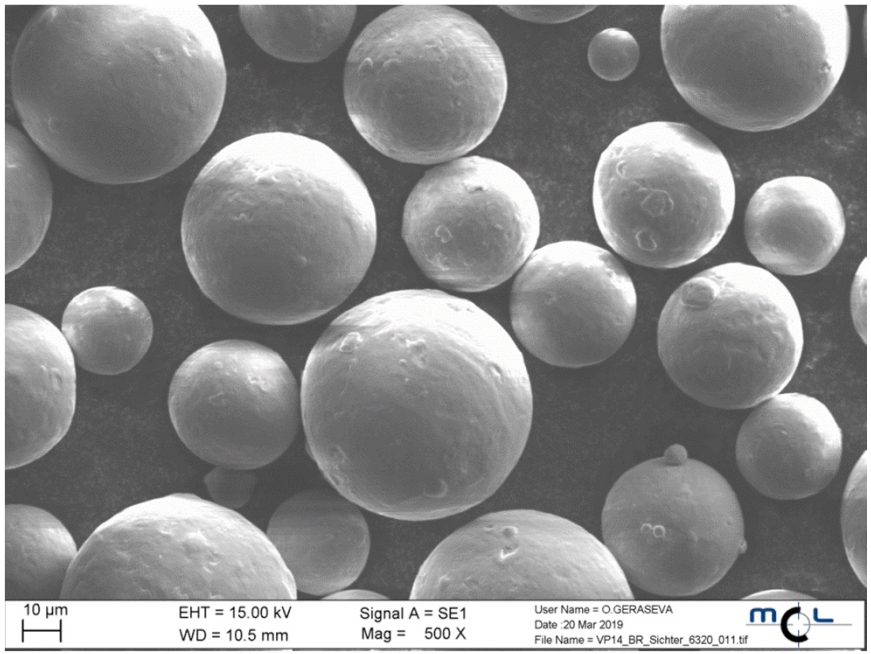


I. Spherical Particles (?):

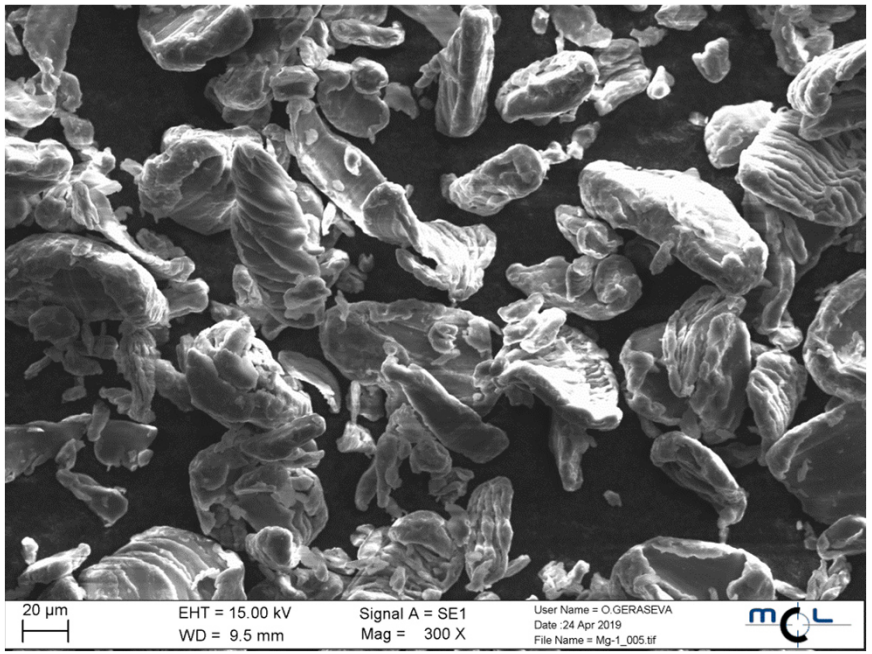
Why spherical?

- Good Flowability
- Low Specific Surface Area → Less Surface Impurities (Oxygen, Nitrogen, etc.)
- Better Predictable

But: Melting Rate is Higher for Irregular Powders



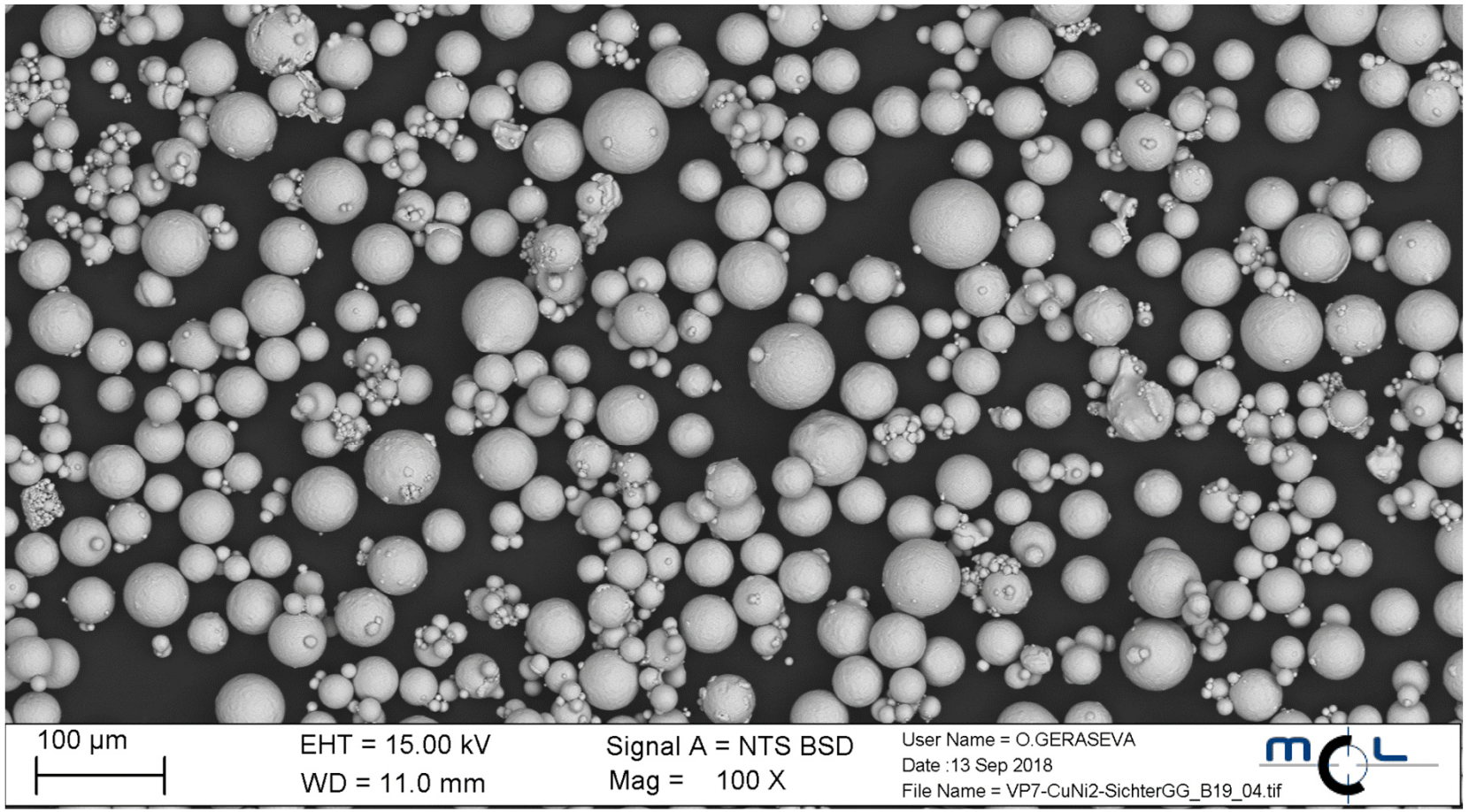
Metalpine Spherical Powder (CuCr1Zr)



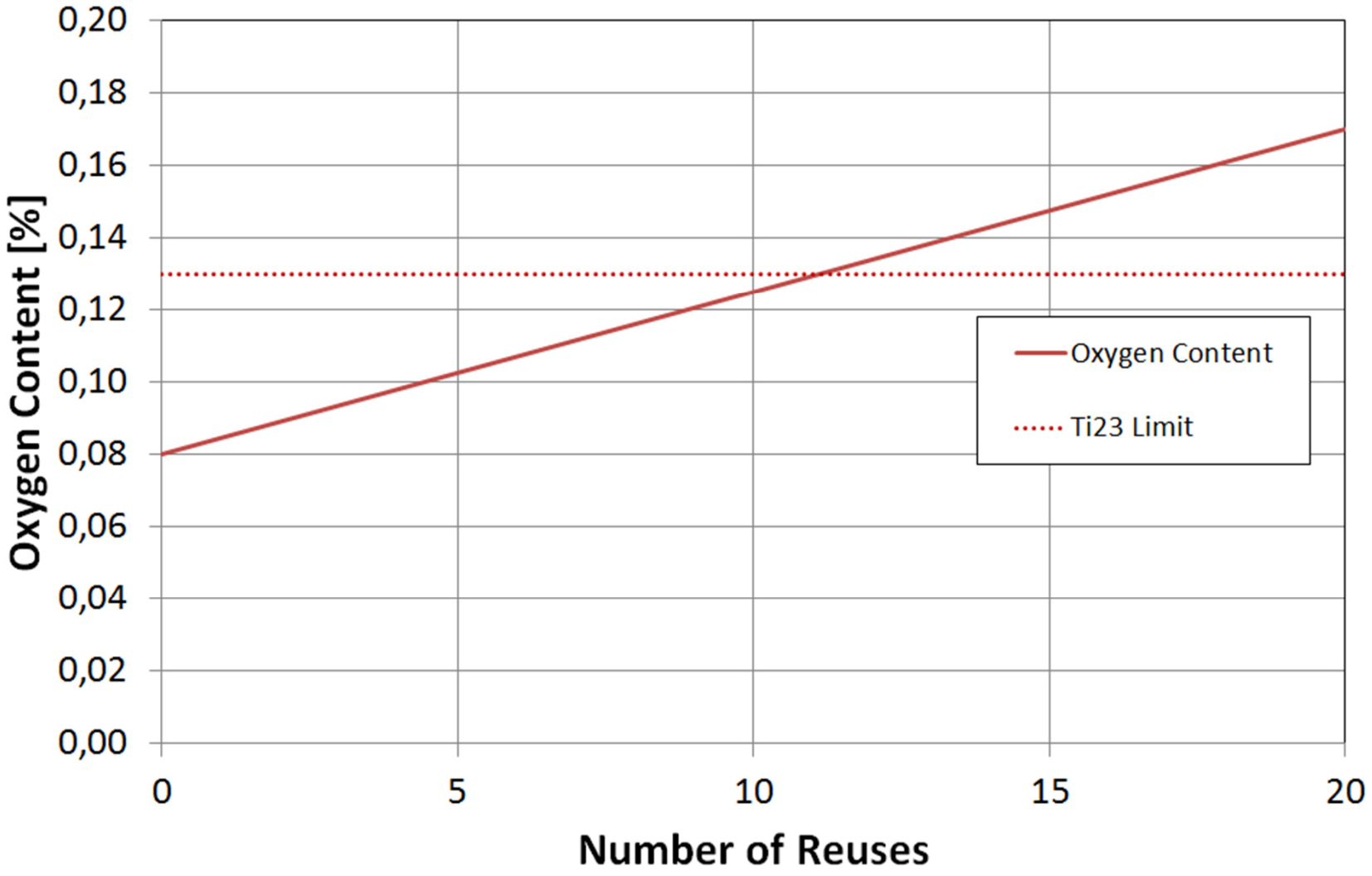
Non Ferrum Ground Powder (Mg)

II. Satellite-Free / Agglomerate-Free Powders:

- Better Flowability, Predictability
- Less Pores in the Built Part
- Evaporation Rate is Lower



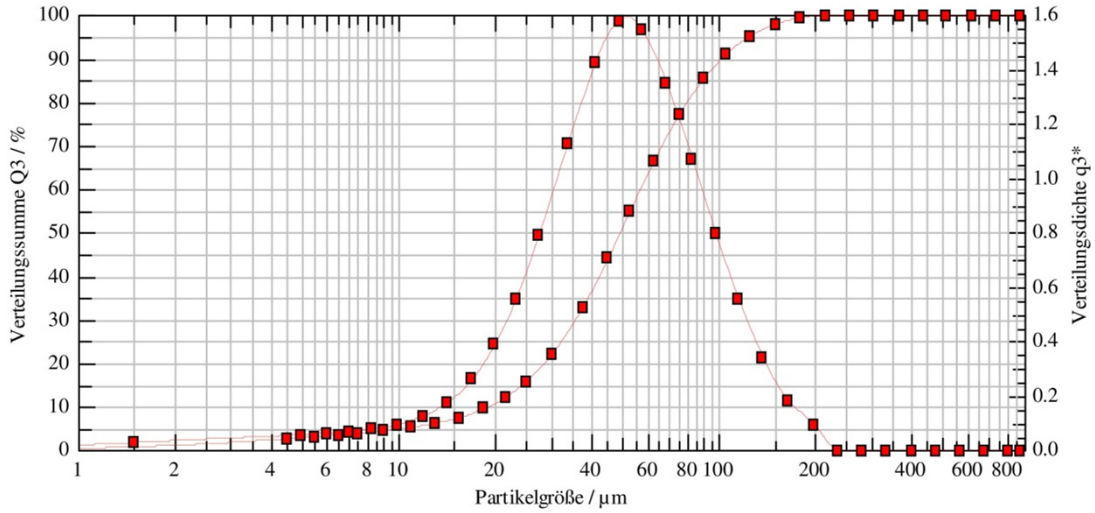
III. Low Oxides, Nitrides, „no“ Impurities, no Cross Contamination



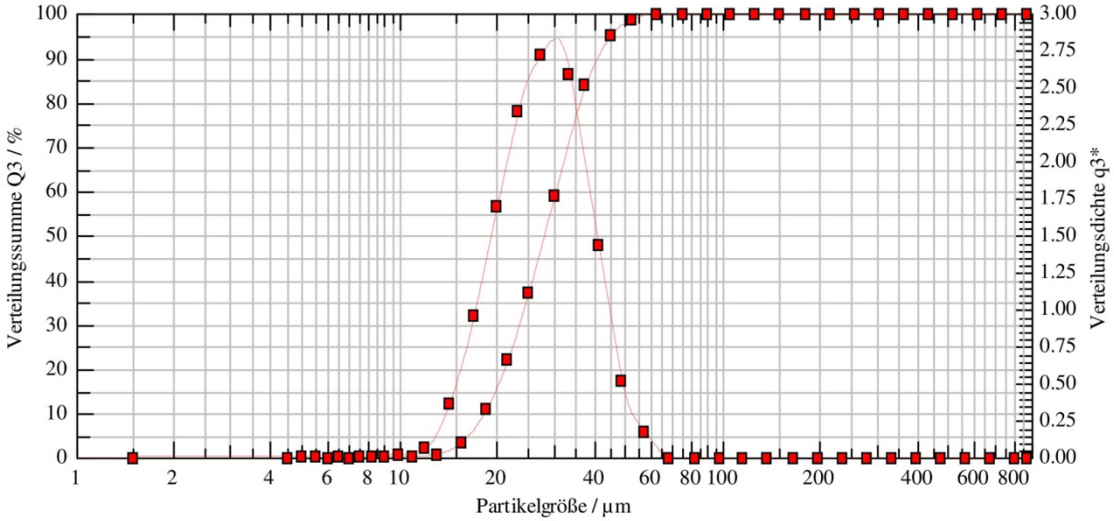
IV. Narrow Particle Size Distribution

→ Low Yield (often <30%)
→ Higher Pricing
→ Bad Repeatability

as atomised



15-45µm for AM



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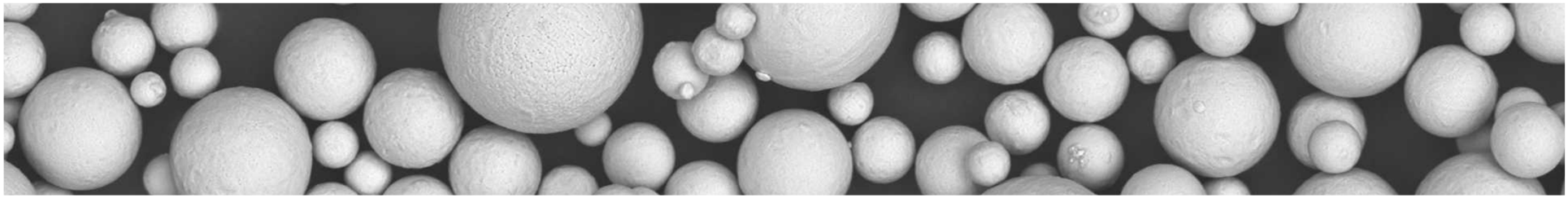
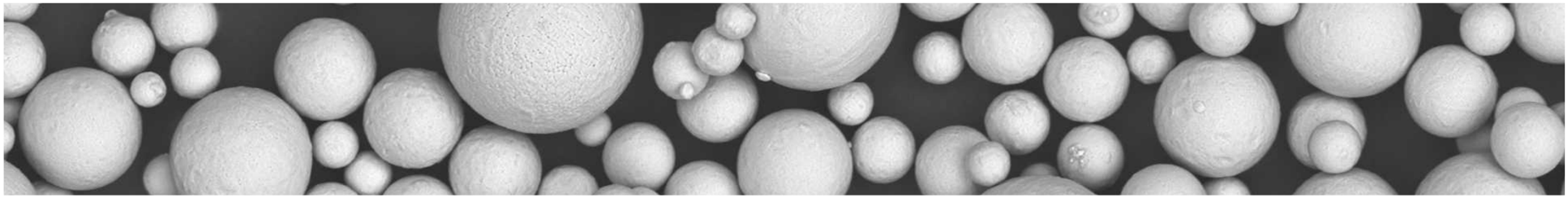


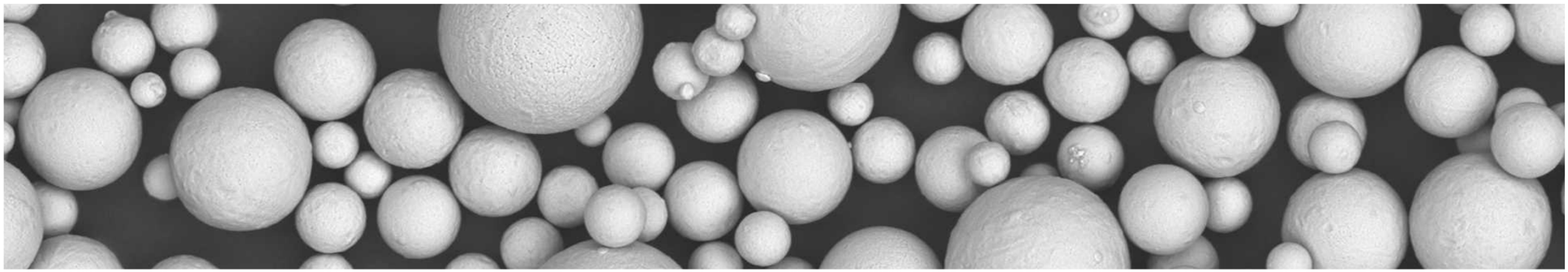
→ Powder production via gas atomization is an old technique (> 100 years)
→ Energy efficiency is really, really bad
→ Contemporary requirements on powders are
- Spherical Particles
- Satellite-Free / Agglomerate-Free Powders
- Low Oxides, Nitrides, „no“ Impurities
- Narrow Particle Size Distribution

→ These requirements cannot easily be accomplished by standard production facilities



Metalpine Powder Production Process:

- → Crucible-free Atomization Process
- → Argon Atomization
- → Low Oxides, Low Nitrides (Classifying, Screening and Packaging under Argon)
- → Contamination-free Process
- → Perfectly clean Production Environment
- → Spherical Powders (Perfect Flowability)
- → Reproducible Quality, even at Minimum Sample Sizes (>2kg)
- → Narrow Particle Size Distribution
- → Particle Sizes Adjustable to Customer Requirements
- → A Multitude of Materials is Available

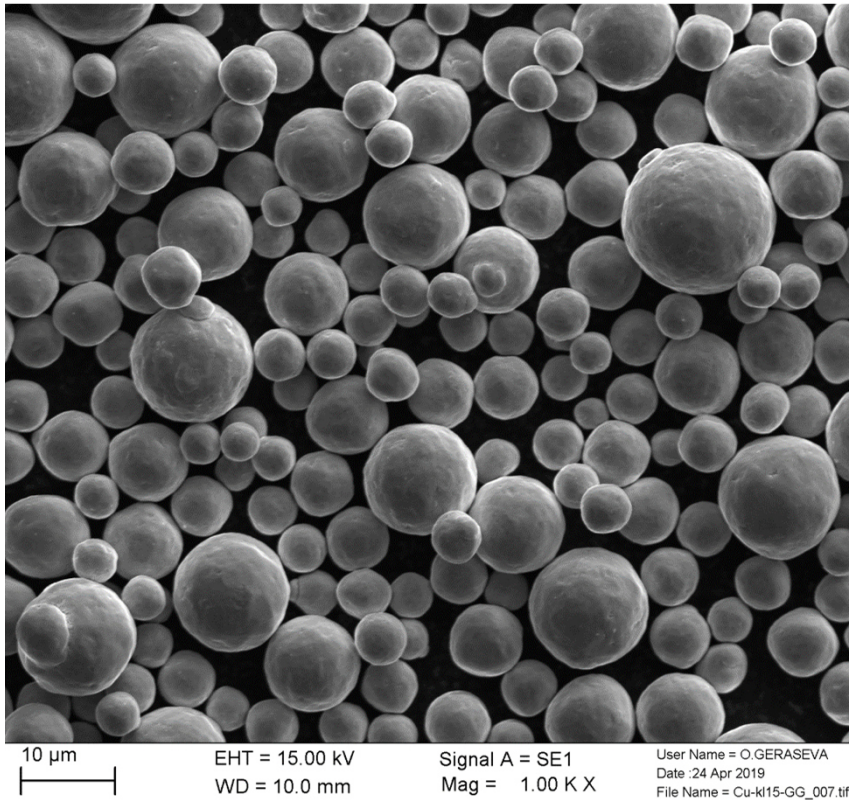


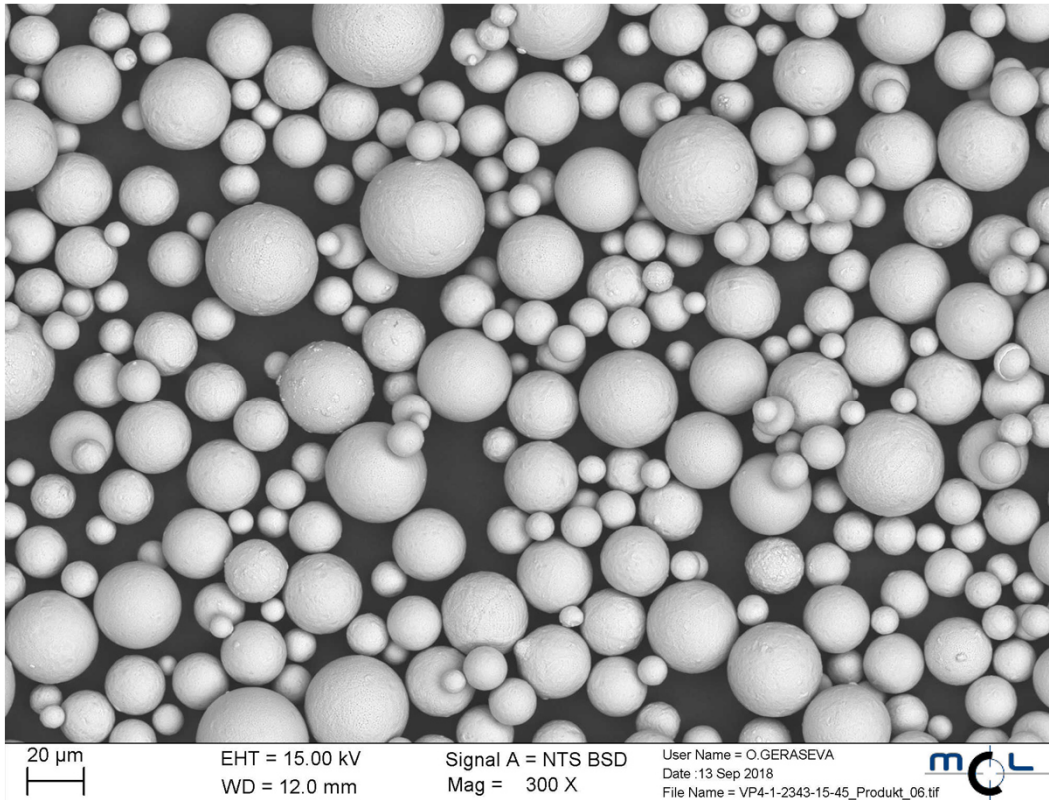
Materials (Examples):

- Copper Alloys (OF-Cu, CuCr1Zr, CuNi2SiCr)
- Titanium Alloys (Ti1, Ti5, Ti23)
- Molybdenum 99,9%
- Stainless Steels, e.g. 316L, 17-4PH, 1.4317
- Tool Steels: e.g. 1.2343
- Nickel Based: IN625, IN718

Particle Sizes:

- 20-63µm
- 15-45µm
- 10-30µm
- <15µm
- Others on request





Perfecly Clean Production Environment
in the South-East of Austria, Graz

Location:

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8020 Graz | Austria
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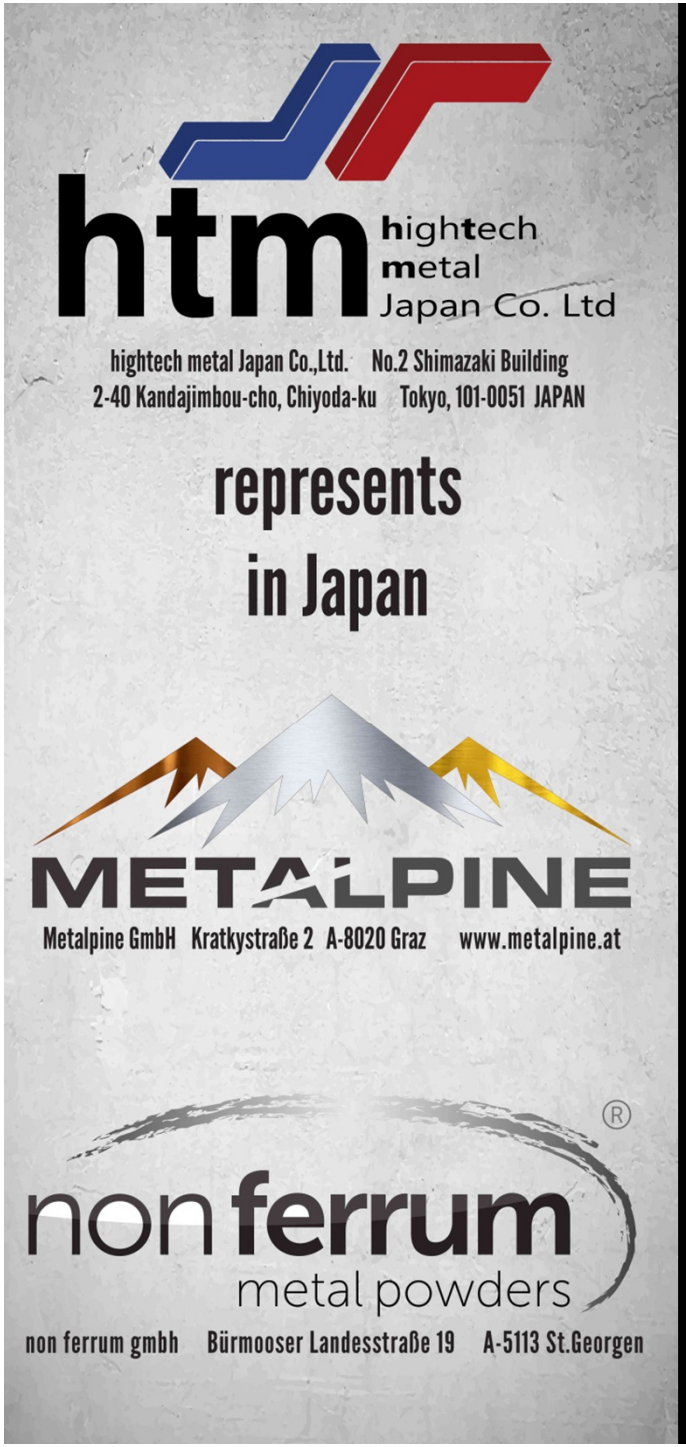

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