Atomization of Reactive and Refractory Metals/Alloys

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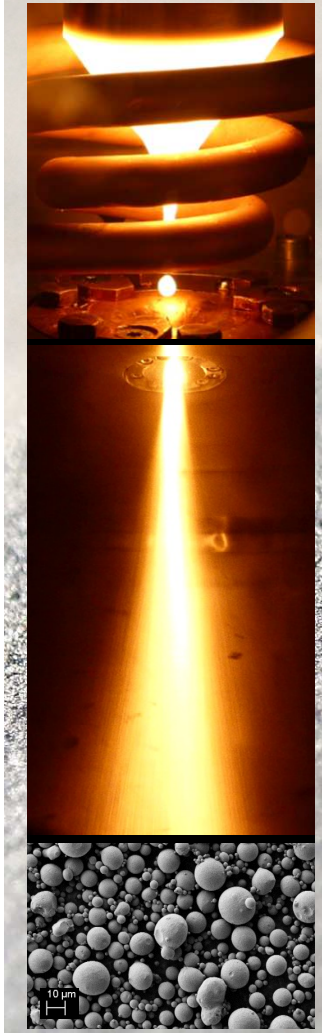


- Introduction
- EIGA – Technology
- Refractory Metals
- Titanium Alloys
- Summary & Outlook

Introduction

Reactive Metals: e.g. Ti, Zr, Hf

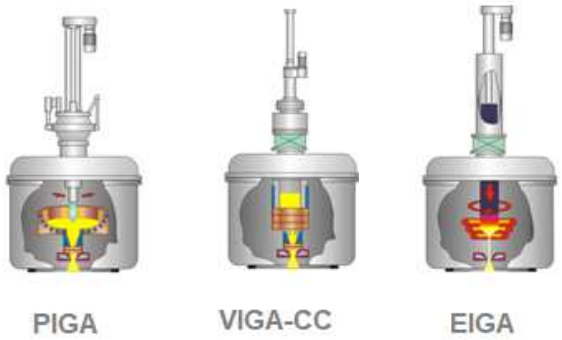
Refractory Metals: e.g. Nb, Ta, Mo, W

- Spherical powder with good packing density and flowability
- Low gas porosity
- High reactivity with oxygen, nitrogen

→Risk of formation of non-metallic inclusions

- Low oxygen, nitrogen contents in powder
- High melting points 1700 – 3400 °C

→Cold Wall or contact free melting and atomization



Introduction

Electrode **I**nduction Melting Inert **G**as **A**tomization - EIGA

Pre-alloyed electrode

Induction coil

Gas Nozzle

Atomization Zone

Atomization Tower

Inert Gas Exhaust

Powder Transport

Cyclone Separator

Powder Collector

FEEDSTOCK

- Electrodes:
  20 – 100 mm Ø and 300 – 1000 mm length

PROCESS

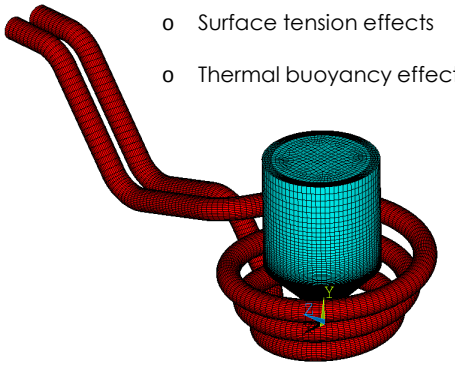
- <u>Melting:</u> lowering of the electrode into a conical induction coil and crucible-less induction melting of the electrode tip
- <u>Atomization:</u> molten metal stream falls into the "free-fall" nozzle and is atomized by the high-pressure inert gas

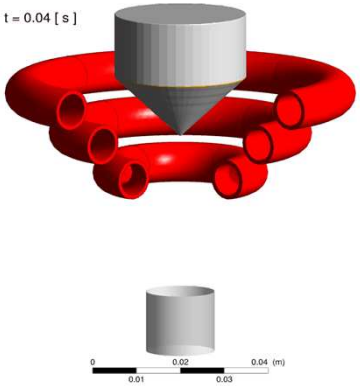
FEATURES

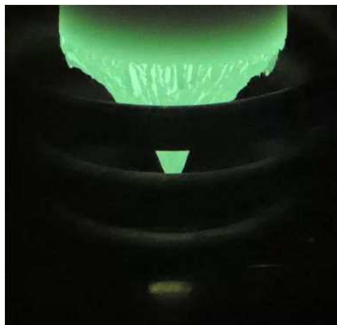
- Spherical, clean powder
- Robust, reliable, reproducible
- Ceramics and contact-free
  → reactive alloys ("state-of-the-art" for Ti)
  → high melting T (refractory metals)

Refractory Metals

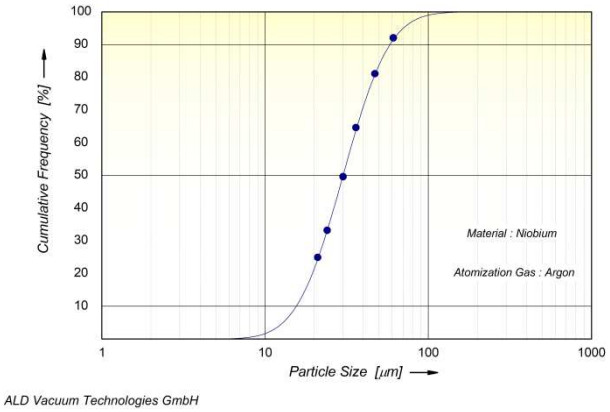
- Extension of EIGA-technology to refractory metals/alloys (e.g. Niobium, T_m : 2477 °C)
- Coupled numerical model that precisely describes the EIGA process (incl. droplet detachment)
  - Resolution of the flow inside droplets
  - Surface tension effects
  - Thermal buoyancy effects
  - Marangoni stress (to be implemented)







In collaboration
with ETP Hannover



Rod Diameter 50 mm

D_{50} : 30-35 µm

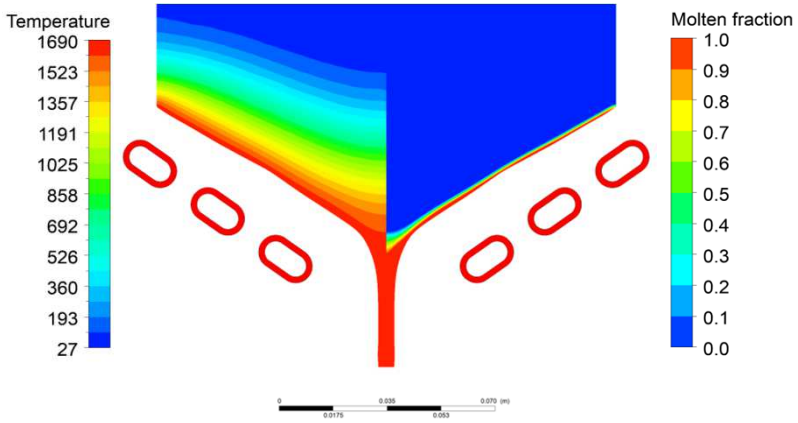
σ : 1.5 – 1.7

Titanium Alloys - Large Electrode Diameters

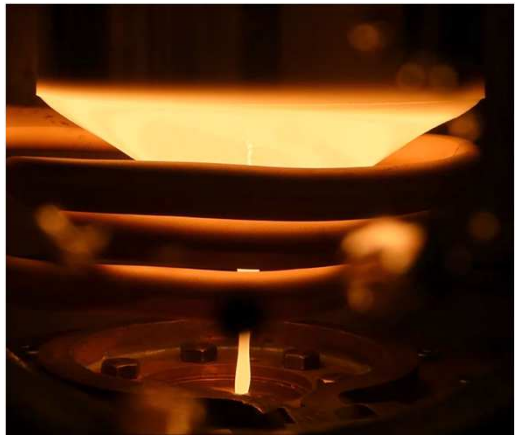
- Driving force : significant reduction in specific gas consumption → cost reduction
- Scale up of electrode diameters for Titanium and Titanium Alloys
- Coil, resonance circuit and power supply tuning by numerical simulation

Ti 64 (T_m : 1660 °C)

Simulation Electrode ∅150 mm

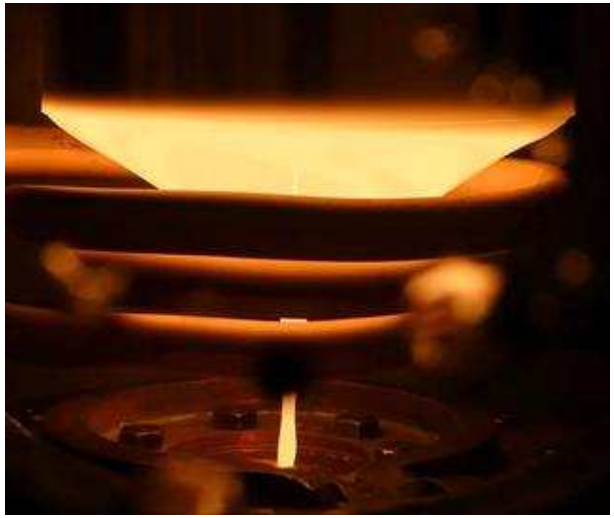


Experiment ∅150 mm Ti64



Titanium Alloys - Large Electrode Diameters

Electrode Diameter 150 mm
Melt Rate : 2.5 kg/min (achieved)



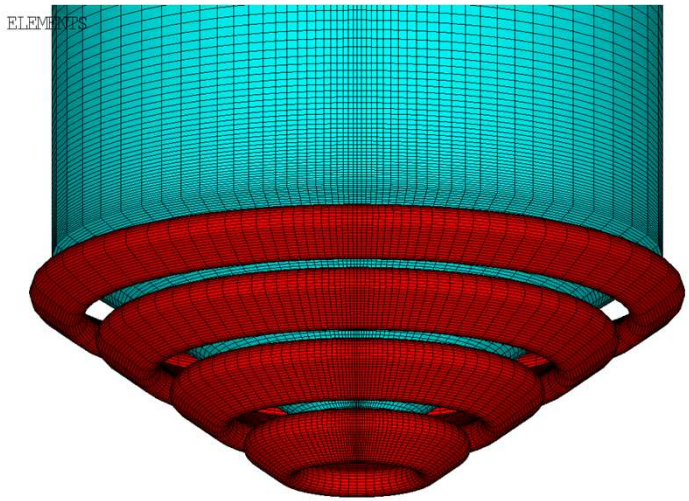
Electrode diameters closer to industrial scale

Cast electrodes possible

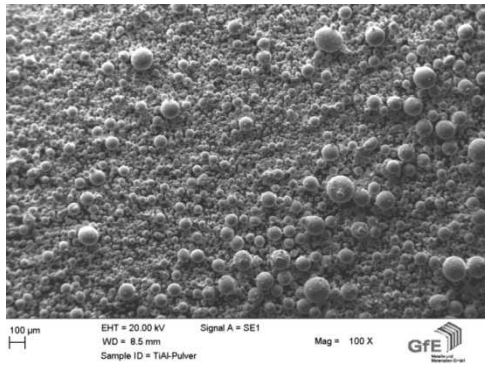
Production rates up to 300-400 kg/hour

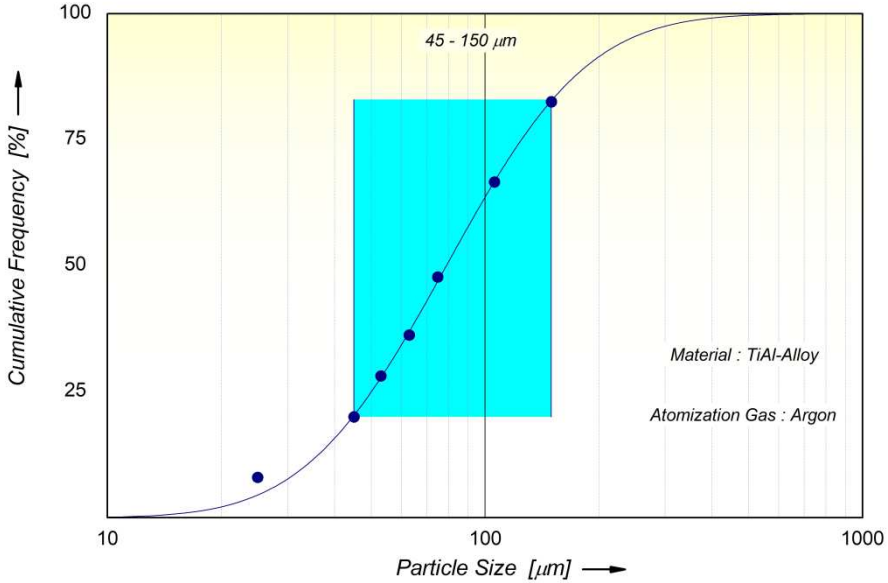
Free fall atomization⇒
Impact on fine powder yield to be minimized

Electrode Diameter 250 mm
Melt Rate : 5-6 kg/min (target)



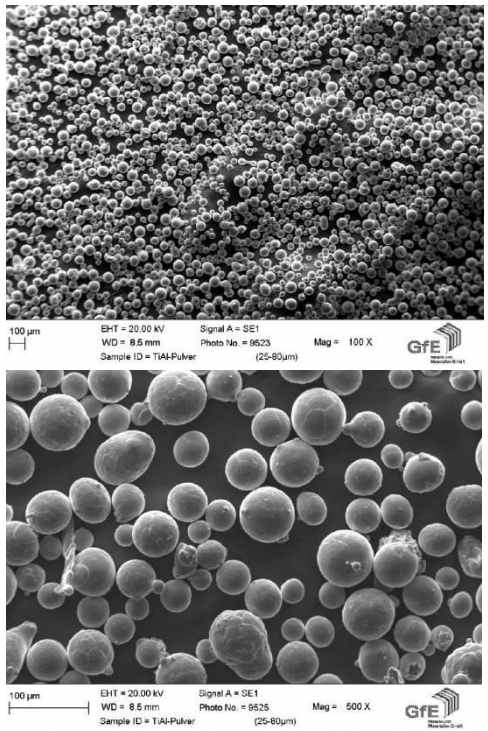
Titanium Alloys - Powder for EBM

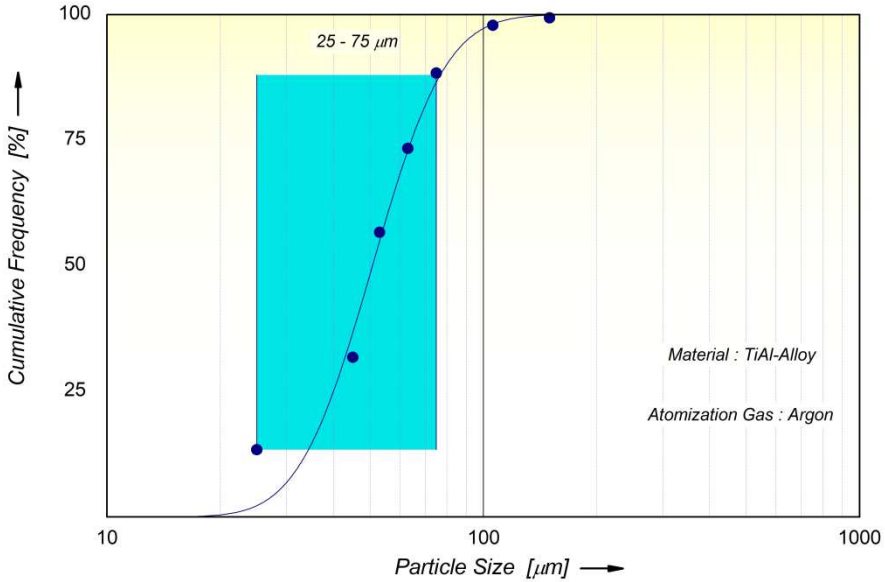




- 55 % yield for 45- 150 µm
- Argon-consumption : < 500 std. m^3/ h
- Flow test : 32.0 sec / Apparent density : 2.21 g/cm^3

Titanium Alloys - Powder for SLM





- 65% yield for 25-75 µm
- Argon-consumption : < 750 std. m^3/ h
- D_{50} : around 50 µm

Summary and Outlook

- EIGA-Technology (EIGA-PREMIUM) provide means for significant reduction of powder costs for titanium alloys (e.g. TiAl , Ti64)

  Scale up of feedstock electrodes

  Powder yield can be maximized according to application requirements

- No limits for materials to be atomized - As long it couples it will become powder
- AMG-Technology covers all aspects of powder production for AM-Industry

  GfE – Aerospace industry certified powder supplier for Titanium alloys (whole value chain → tailor made powders possible)

  ALD – Leading equipment supplier for powder production with inert gas

- Further reduction of specific gas consumption and new atomization technologies will be next

Thank You for Your Attention