Ceramic-Free Metal Powder Production

for Reactive and Refractory Metals

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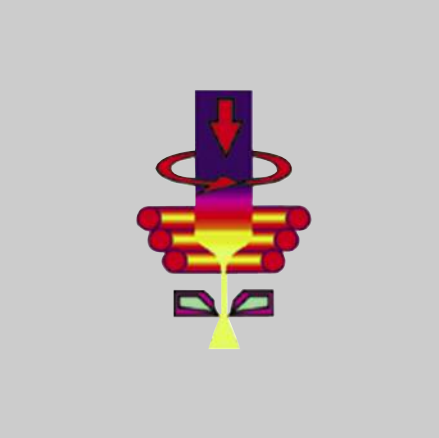


Introduction
Reactive alloys can not be melted and processed in ceramic crucibles due to the reactions between the melt and the ceramic lining. Also ceramic melting for refractory alloys is not possible due to the high melting point of these alloys.
In order to overcome the "ceramic problem" it is necessary to use melting techniques and melt nozzle systems where the melt is not in contact with ceramic lining materials at all. For this reason, ALD Vacuum Technologies AG has developed melting processes and nozzle systems which enable to melt and atomize reactive or refractory alloys in a ceramic-free environment.

Applications
Applications for ceramic-free powders are sputter target production, laser sintering, MIM for medical parts and protective coatings. But extremely pure metal alloys are also needed for the production of highly stressed components in aerospace and aviation industry.

These powders have to fulfill highest quality criteria such as:

- **Spherical Shape**
- **High Cleanliness**
- **Rapid Solidification**
- **Homogeneous Microstructure**

Materials
Typical materials which need ceramic-free production processes are for example Ti, TiAl, Zr, Nb, FeGd and FeTb.

Process
High purity ceramic-free metal powders can only be produced via atomization in a high purity process atmosphere, i.e. under Argon, Helium or Nitrogen. For the atomization a specially designed gas nozzle is used, to achieve a high yield of fine powder. The yield of fine powder is substantially higher compared with rotary atomization processes (i.e. PREP).

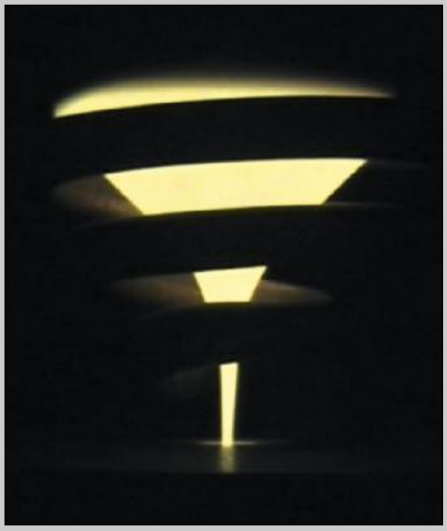
The melting processes which are applied to ceramic-free metal powder production can be divided into:

- **Melting without any crucible (EIGA) using pre-alloyed electrode feedstock material**
- **Melting using a watercooled copper crucible (PIGA, ESR-CIG, VIGA-CC) using typical charging materials**

The Atomization System
Every ceramic-free melting process can be combined with ALD's modular atomization system components, which have been proven in daily powder production operation for over 30 years. Common general features of ALD's atomization systems are:

- **High operational flexibility**
- **High degree of vacuum tightness**
- **High separation efficiency of the cyclone system**
- **Good accessibility for cleaning and maintenance**
- **Modular Design**

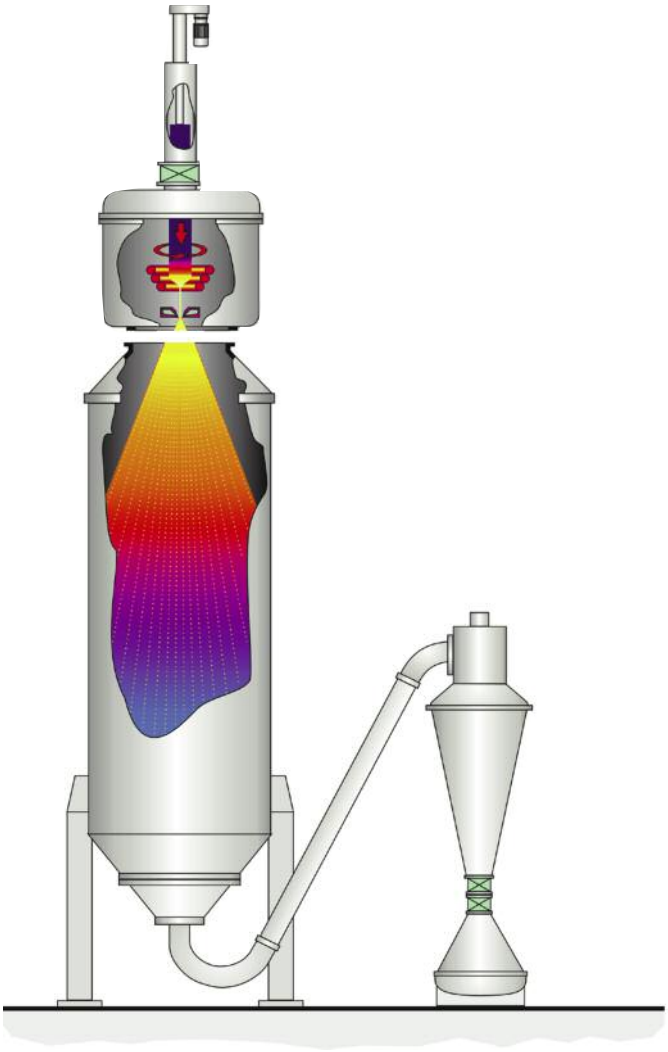
EIGA 50/100 -
Electrode Induction-Melting Gas Atomization
The EIGA system 50 /100 applies acrucible free melting & atomization technique.
The EIGA process uses pre-alloyed rods (cast, remelted or sintered) as the electrode feedstock material. The melting of the feedstock electrode is accomplished by lowering the slowly rotating electrode into a conical induction coil. The stream of molten metal flows directly into the atomization nozzle system where it is atomized by a high kinetic energy inert gas jet.
The feed rate as well as coil design and electric process parameters can be optimized with regard to the feedstock material.
Additionally it has to be emphasized, that nearly every metal can be inductively melted and atomized with the EIGA system 50/100, resulting in a broad range of potential applications. The melting and atomization process can be visually observed through several view ports.
A quasi-continuous production mode can be realized by a load lock magazine which is flanged on top of the EIGA melting chamber.



- **EIGA 100mm Ti**
  (courtesy of Helmholtz-Zentrum Geesthacht)

Ceramic-Free Melting System without Crucible

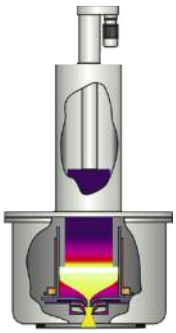
EIGA



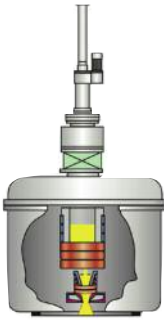
Ceramic-Free Melting Systems with Watercooled Copper Crucibles

PIGA

ESR-CIG



VIGA-CC



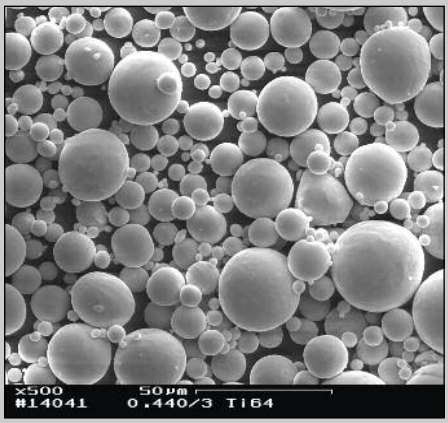
The ceramic-free melting processes of ALD, using water cooled copper crucibles for melting and copper based melt nozzle systems, have already been implemented for the production of reactive powders as well as for the ceramic-free atomization of superalloys.

Plasma **M**elting **I**nduction **G**uiding **G**as **A**tomization - **PIGA**
Plasma melting torch on top of a water cooled copper crucible. The crucible bottom is directly connected to an inductively heated discharge nozzle system. This nozzle system is called **C**old wall **I**nduction **G**uiding (CIG) system, which guides the metal stream ceramic-free into the atomization gas nozzle.

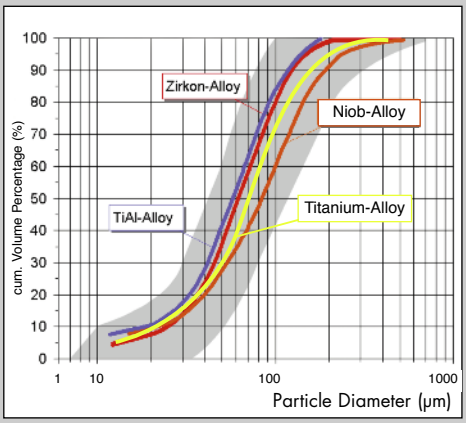
Electro-**S**lag **R**emelting **C**old wall **I**nduction **G**uiding - **ESR-CIG**
ESR melting is used for the refining of superalloys and high grade steels. ESR-CIG enables to combine the ESR refining melting step with the benefits of the ceramic free CIG system.

Vacuum **I**nduction **M**elting **G**as **A**tomization based on **C**old **W**all **C**rucible Technology - **VIGA-CC**
Cold Wall Crucible Technology is used for the production of Ti- or TiAl based alloys. The VIGA-CC combines a bottom pouring cold wall crucible with a ceramic free CIG system.

■ **Feedstock material in various dimensions can be processed and atomized in the EIGA**



■ **Ti grade5 EIGA powder**
(courtesy of Helmholtz-Zentrum Geesthacht)



■ **Particle Size Distribution of various Alloys**

Technical Data

	EIGA 50	EIGA 100
Base area	4,000 x 5.000 mm	5,000 x 6,000 mmm
Height	6,500 mm	7,500 mm
Attainable ultimate vacuum	10^{-2} mbar	10^{-2} mbar
Power requirement	80 kVA	250 kVA
Cooling-water requirement	80 l/min	120 l/min
Cooling-water pressure	5 bar	5 bar
HF power	50 kW	200 kW
Electrode diameter	≤ 50 mm	≤ 100 mm
Electrode length	≤ 800 mm	≤ 1000 mm

■ **EIGA 50 – Electrode Induction Gas Atomizer for Reactive and Refractory Metals**

■ **Cyclone for separation of the atomized powder with powder collecting container**

The Process Control System

The evacuation, melting and atomizing processes are monitored and controlled by means of a state-of-the-art PLC control system. The control system enables on-line process monitoring, data-logging and trend analysis. Besides the level of system and process know-how in the field of metal powder technology, the reputation of ALD Vacuum Technologies rests squarely on this added factor of process control.

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