

0.4.2009: 11.05.2009: 11.05.2009: 11.05.2009  
5.11. - 6.11.2008 (HVOF)  
Erding (dts)  
SMA, AP



## Cold Spray – Selected R&D Results and Industrial Applications

### Topic

1. Introduction	
2. Selected R&D Topics	
3. Examples of Industrial Applications	
4. Subjects for Development	

# 1. Introduction

## GfE sites

### GfE Gesellschaft für Elektrometallurgie mbH



**Freiberg / Saxony**  
GfE Fremat GmbH



**Brand-Erbisdorf near Freiberg**  
Production



**Nuernberg / Bavaria**  
GfE Gesellschaft für Elektrometallurgie mbH  
GfE Metalle und Materialien GmbH



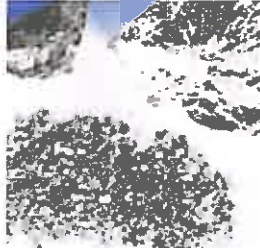
- Diversified manufacturer of high performance metals and materials
  - Scientific technical services
- 
- € 97m (\$ 140 m) revenues in 2007
  - 400 employees
- 
- Founded 1911 by Paul Grünfeld
  - Headquarter in Nuernberg  
2. location Freiberg
  - Sales offices in USA and China
  - Worldwide distribution network via sales partners

# 1. Introduction

## Divisions



Master Alloys



Chemicals



Powders



Coating Materials



Scientific  
Technical Service



# 1. Introduction

Business Fields GfE Fremat GmbH



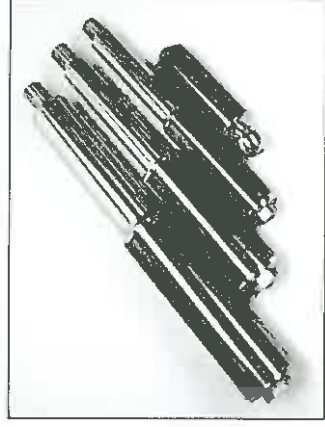
## Coating Materials



## Special Semi-finished Products



## Coating Services



## 1. Introduction

### Coating Services

#### Thermal Spraying Technologies

- Arc Spraying (Arc)
- Powder Flame Spraying (PFS)
- Wire Flame Spraying (WFS)
- High-Velocity Oxy-Fuel (HVOF)
- Atmospheric Plasma Spraying (APS)
- Cold Gas Spraying (CGS)



#### High Performance Production Facilities

- 6 Spraying Booth
- High manufacturing penetration
- Broad technological and material know-how
- User-specific Developments
- Backing by Laboratories and Diagnostics

#### Complete part manufacturing

- Machining
- Cleaning, Grit Blasting, Coating
- Sealing
- Heat Treatment
- Grinding and Polishing

## 2. Selected R&D Topics

### CGS R&D Topic

#### Cold Sprayed Coatings on Hard Substrates

(Al, Ti on Glass, Ceramics)

##### Applications:

1. Ti Coatings on Monolithic Ceramic Medical Implants
2. Heating Layers on Glass.
3. Electrical Contacting Layers for Photovoltaic or other Thin Films

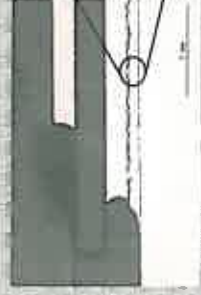


#### Cold Sprayed Coatings for Power Electronics

##### Applications:

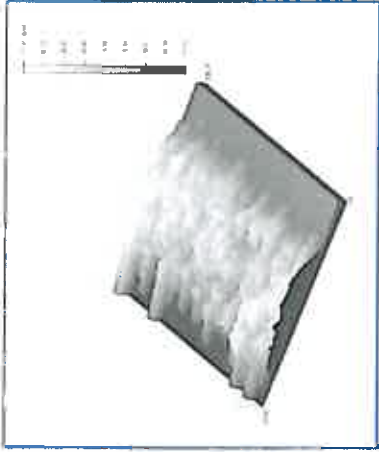
Conducting Layers on Power Electronic Heat Sinks for

1. Compensation of CTE Mismatch
2. Solderability

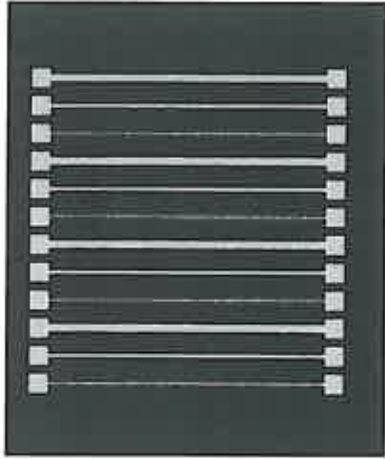


## 2. Selected R&D Results

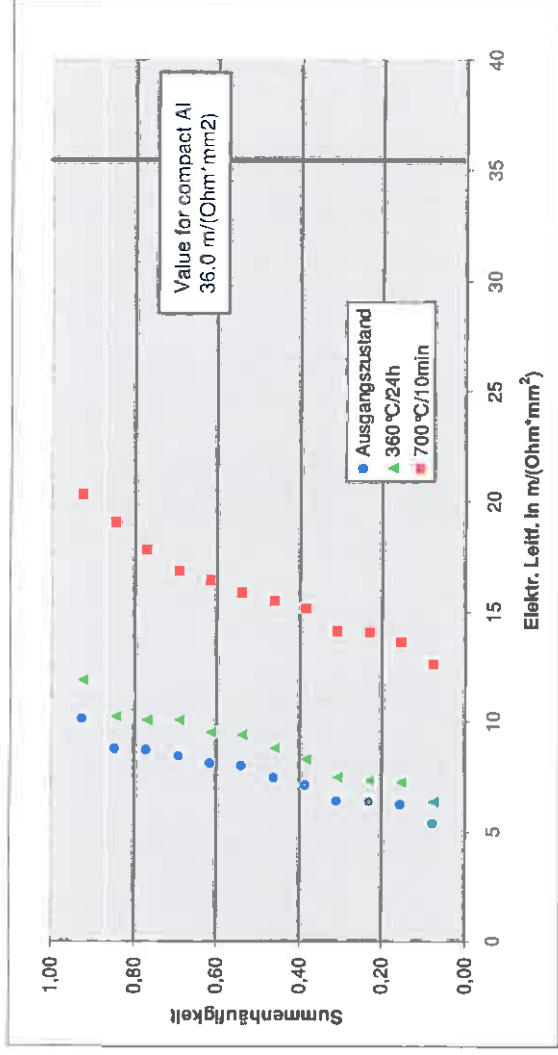
### Cold Sprayed Coatings on Hard Substrates



Laser Scan of a Conductor Line



Sample Layout for Measuring of Electrical Conductivity of Al on Float Glass

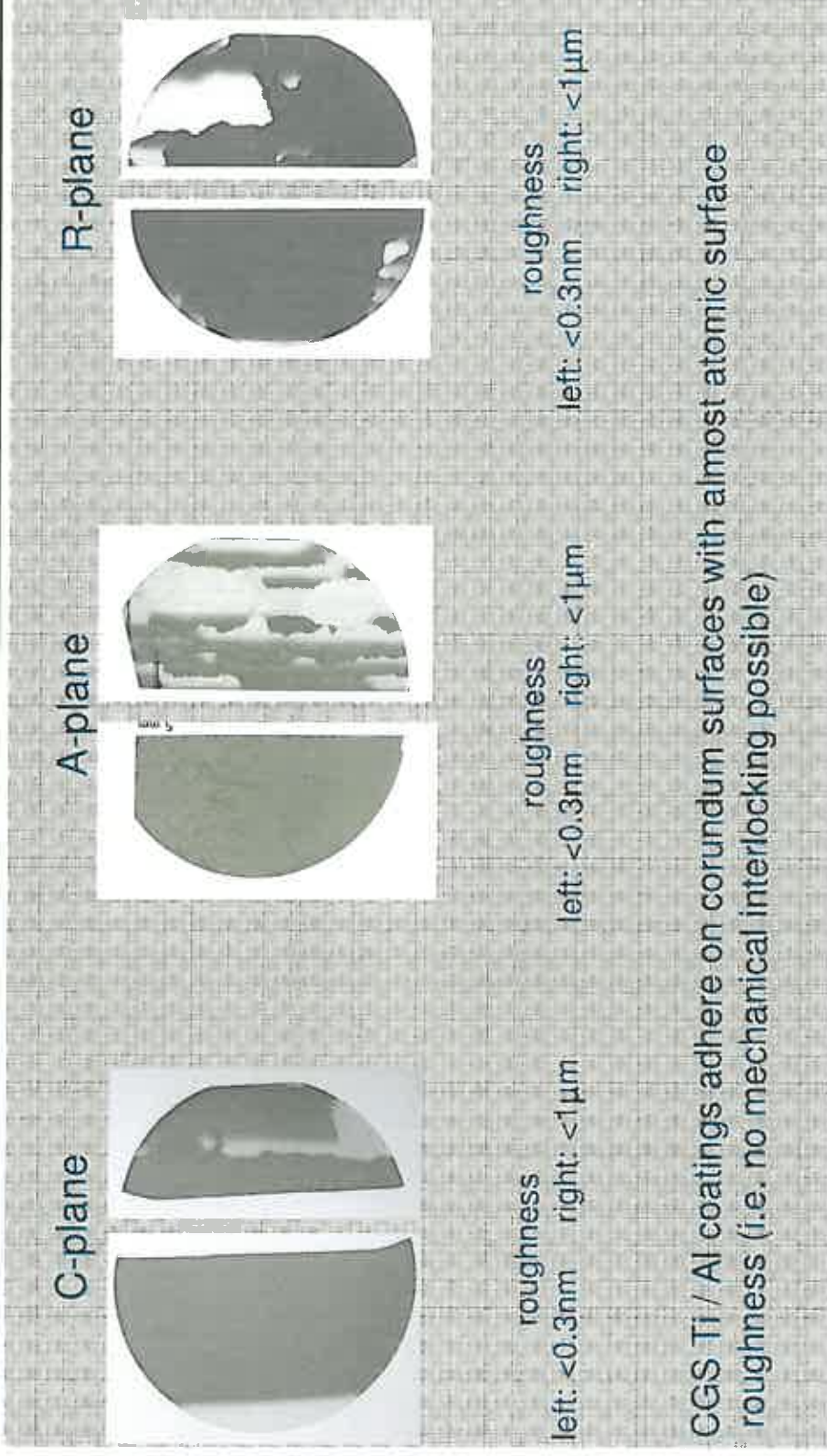


- Cold Sprayed Al on Glass
- 25% Electrical Conductivity (without Heat Treatment)
- No reduction of Conductivity after 200h Damp-Heat-Test
- High Strength and Bonding Strength

## 2. Selected R&D Results

### Cold Sprayed Coatings on Hard Substrates

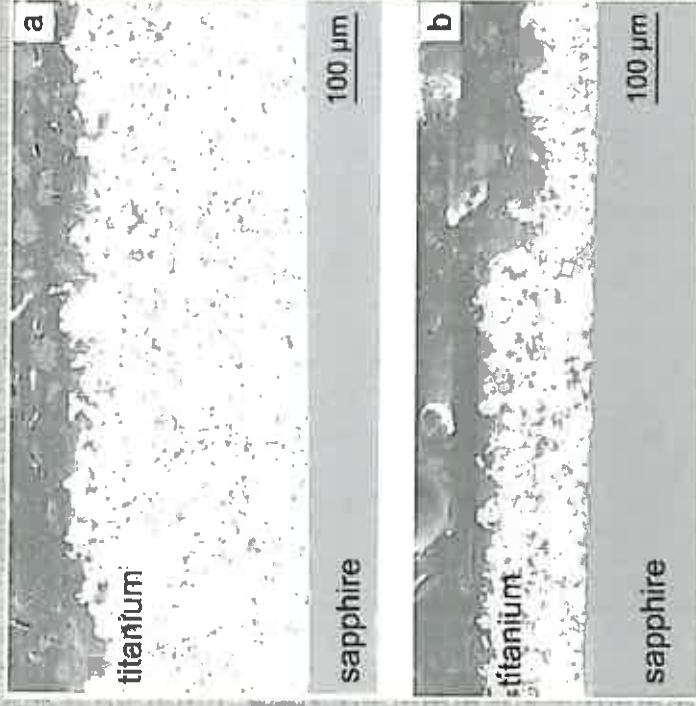
#### Effect of the surface roughness – CGS-Ti on sapphire substrate



## 2. Selected R&D Results

### Cold Sprayed Coatings on Hard Substrates

#### Effect of the surface roughness – CGS-Ti on sapphire substrate



Polished side ( $R_a < 0.3 \text{ nm}$ )

Uniform thickness of the coating of  $250 \mu\text{m}$

Ground side ( $R_a < 1 \mu\text{m}$ )

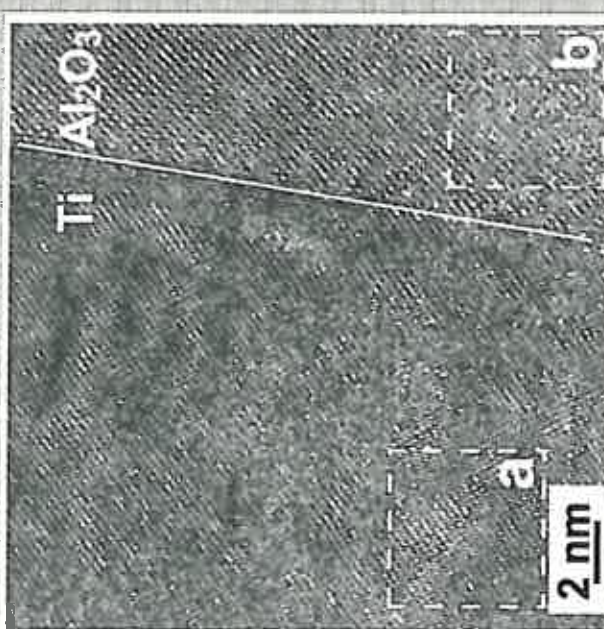
Non-uniform thickness of the coating of  
max.  $150 \mu\text{m}$

Much better adhesion on the polished substrate

## 2. Selected R&D Results

### Cold Sprayed Coatings on Hard Substrates

**CGS-Ti / Sapphire Interface (HRTEM)**



**Ti** | **Al<sub>2</sub>O<sub>3</sub>**


**2 nm**

**Bonding mechanisms between CGS-Ti and Al<sub>2</sub>O<sub>3</sub>**


Strong plastic deformation, especially next to the Al<sub>2</sub>O<sub>3</sub> surface

The generated heat and the plastic deformation result in recrystallization

The crystallites adjacent to the Al<sub>2</sub>O<sub>3</sub> show partial heteroepitaxy due to recrystallization



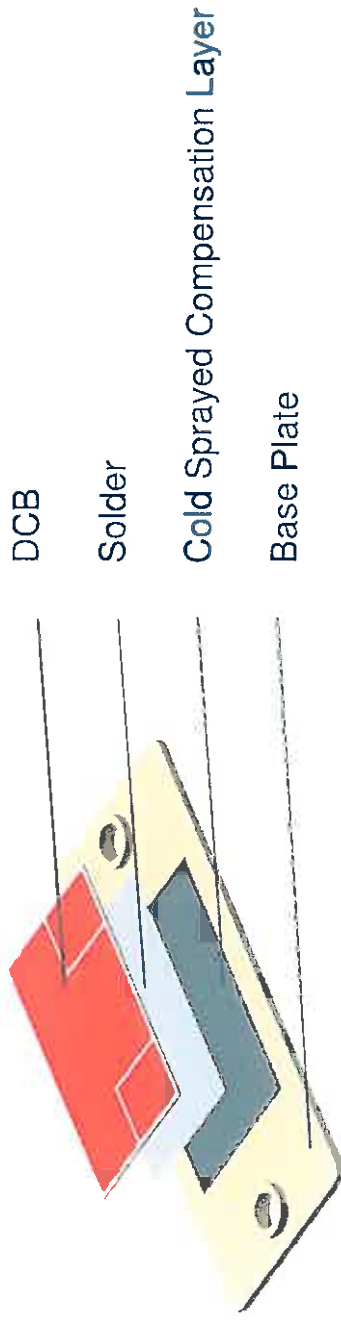
**a**



**b**

## 2. Selected R&D Results Cold Sprayed Coatings for Power Electronics

### Cold Sprayed Intermediate Layers for Compensation of CTE Mismatch



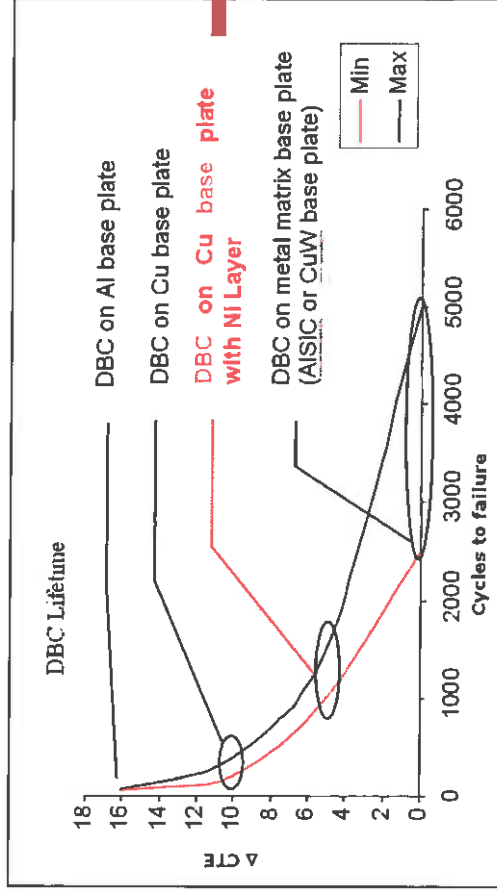
### Scheme of a Modul with Intermediate Compensation Layer

(aus : F. Osterwald, M. Kock, K. Olesen, R. Eisele, Danfoss Silicon Power GmbH, Sprayed Stress Reducing Interlayers for Highly Reliable Large Solder Joints, PCIM Europe 2007)

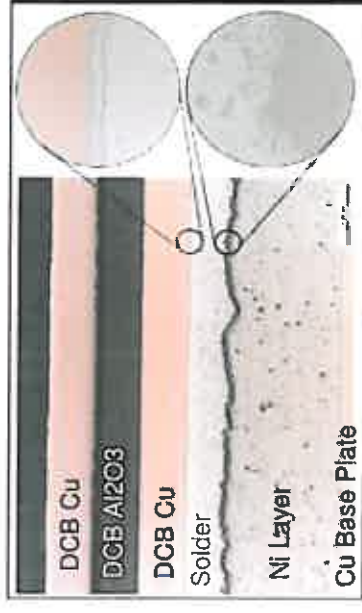
## 2. Selected R&D Results for Power Electronics

### Cold Sprayed Coatings for Power Electronics

### Cold Sprayed Intermediate Layers for Compensation of CTE Mismatch



(Source: F. Osterwald, M. Kock, K. Olesen, R. Eisele, Danfoss Silicon Power GmbH, Sprayed Stress Reducing Interlayers for Highly Reliable Large Solder Joints, PCIM Europe 2007)



Demonstrator with 500 μm Ni intermediate layer

### 3. Examples of Industrial Applications Cu Coatings on Rollers and for Automotive Application



Cu Coating  
as sprayed

- Cold Spray Cu for Engraved Printing Rolls
- Thickness up to several mm
- High Bonding Strength
- Low Oxygen Content
- Excellent Machinability (Turning, Grinding, Finishing)
- Engraveability comparable to Electroplated Copper



Cu Coating  
finished



Cu Coating for Automotive  
Application

### 3. Examples of Industrial Applications Power Electronic Heat Sinks and Refrigeration Units



- Heat Sinks for Power Electronic Applications
- Cold Spray Cu on Al Surface
- High Bonding Strength
- Low Oxygen Content
- Very Good Solderability and Heat Conductivity



- Refrigeration Vessels for apparatus engineering
- Cold Spray Cu
- High Bonding Strength
- Low Oxygen Content
- Very Good Heat Conductivity

### 3. Examples of Industrial Applications Pressure Ring



- Pressure Ring for Food Processing Machine
- Equalising and Bonding Layer for Hardchromium Top Coating
- Cold Spray Cu
- High Bonding Strength
- Low Oxygen Content
- Excellent Machinability

## **4. Subjects for Development Conclusions from Practical Experiences**

- **Enable Long Term Spraying without Interrupts**

Nozzle Fouling for good adhering Powders as Inconel, Al, Ti

Agglomeration of Powders with low Oxygen Content

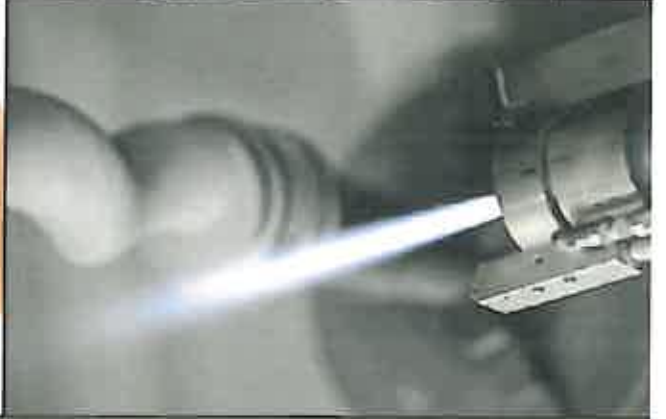
- **Improve Surface Quality for Electronic Applications**

Powder Feeding Equability

Control of Powder Mass Flow

- **Quality Control of Coated Parts**

Implementation of Methods and Equipment for Control of Coating and Surface Properties, Dimensions...



**Thank you !**

**GfE Fremat GmbH  
Freiberg**