

# PARTICOAT

## THEME 4

Nanoscience, nanotechnologies, materials new production technologies (NMP)

Collaborative Project  
Large-scale integrating project

Proposal full title:

**New multipurpose coating systems based on novel particle technology for extreme environments at high temperatures**

Grant agreement no.: CP-IP 211329-2



## Consortium

<i>Beneficiary no.</i>	<i>Beneficiary name</i>	<i>Business</i>	<i>Country</i>
1	Fraunhofer ICT (co-ordinator)	Research	D
2	DECHEMA	Research	D
3	SVÚM	Research	CZ
4	TECNATOM	Industry	E
5	PyroGenesis	SME	GR
6	WIP Prague	Industry	CZ
7	Sibthermochim	SME	RU
8	Universidad Carlos III Madrid	University	E
9	Université de La Rochelle	University	F
10	Turbocoating	SME	I
11	Acciona Infraestructuras	Industry	E
12	Siemens Power Generation	Industry	D
13	Steinbeis R-Tech	SME	D
14	LARCO	Industry	GR



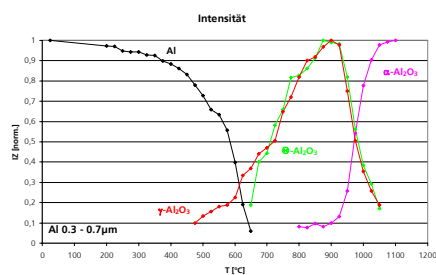
The



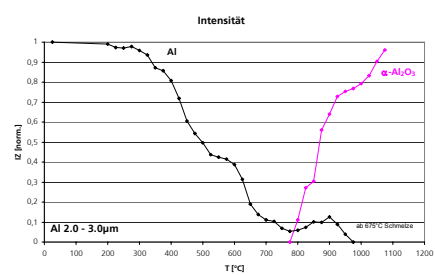
Idea

## The idea: oxidation of nano- and micro-sized Al – particles

Aluminium: 0,3 – 0,7  $\mu\text{m}$

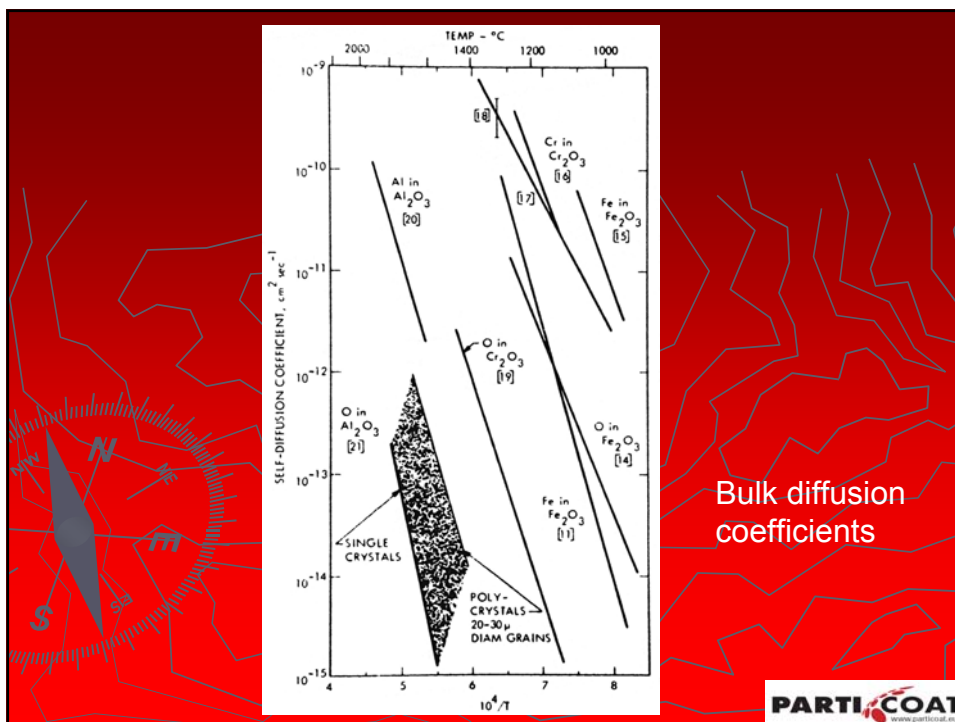
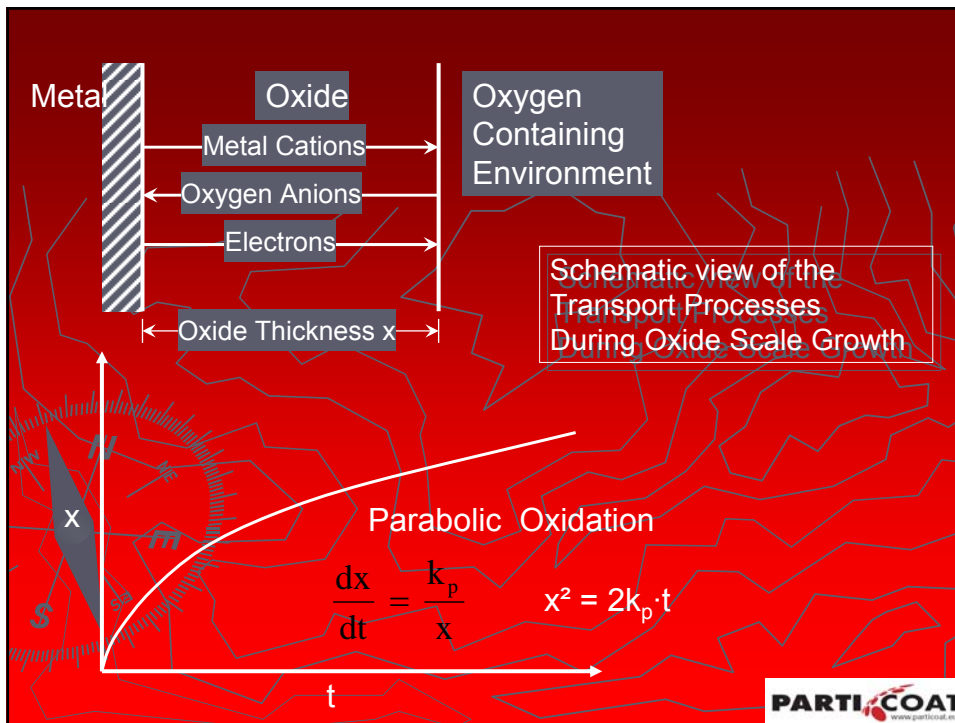


Aluminium: 2-3  $\mu\text{m}$

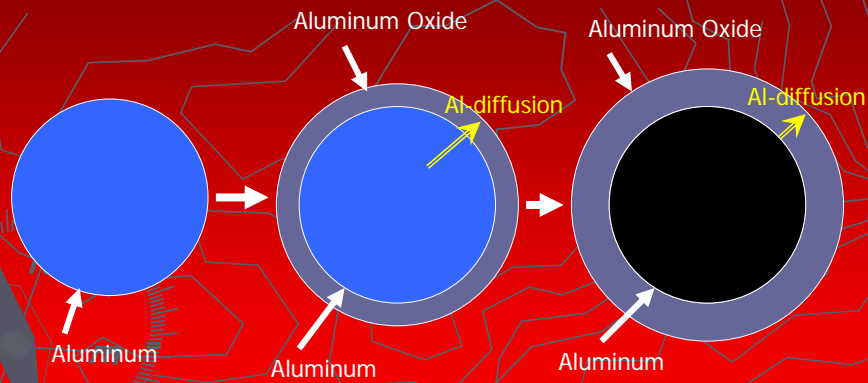


Oxidation on heating from room temperature to 1100°C  
(Microscopy of Oxidation, Birmingham 2005)





## Conversion of Metallic Aluminum Nano/Micro Powder Particles Into Hollow Aluminum Oxide Spheres



*Nano/micro size = low amount of grain boundaries*

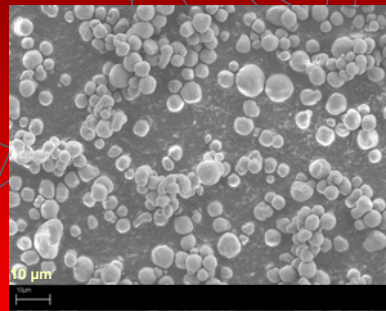
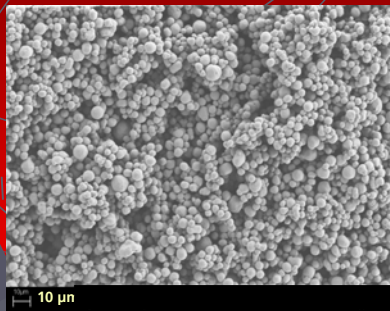
*Aluminum = very creep ductile, i. e. adherence to oxide maintained during conversion*

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## Potential of Nano- and Micro-Scale Metal Powders

Al spherical, 2-3  $\mu\text{m}$

Scanning Electron Microscopy / EDX

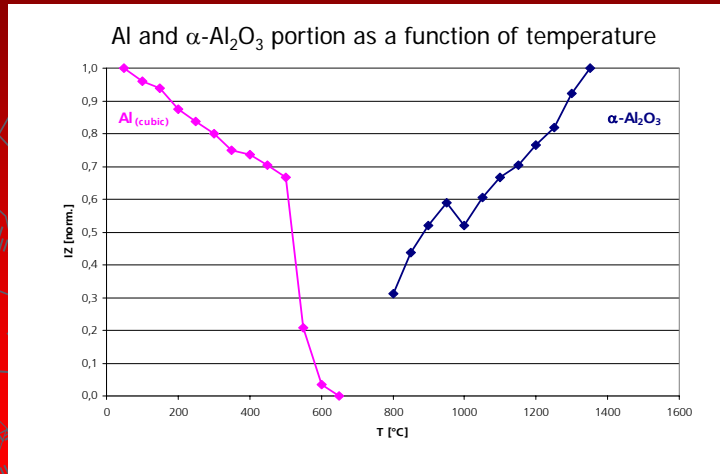


- Homogeneous distribution, no agglomerates
- Spherical particles
- Particle size 2-5  $\mu\text{m}$

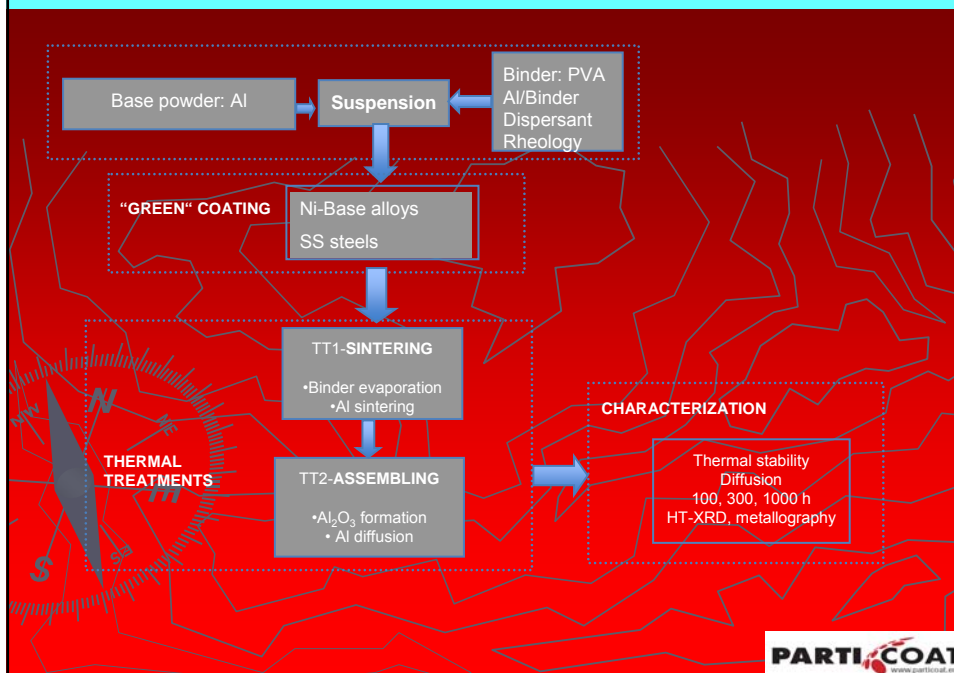
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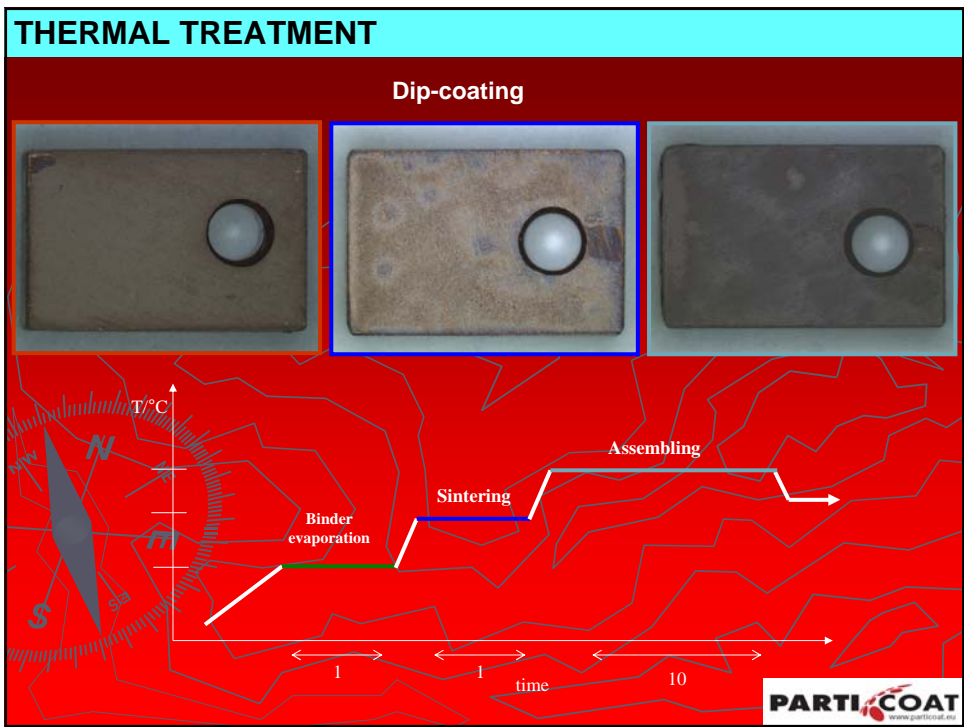
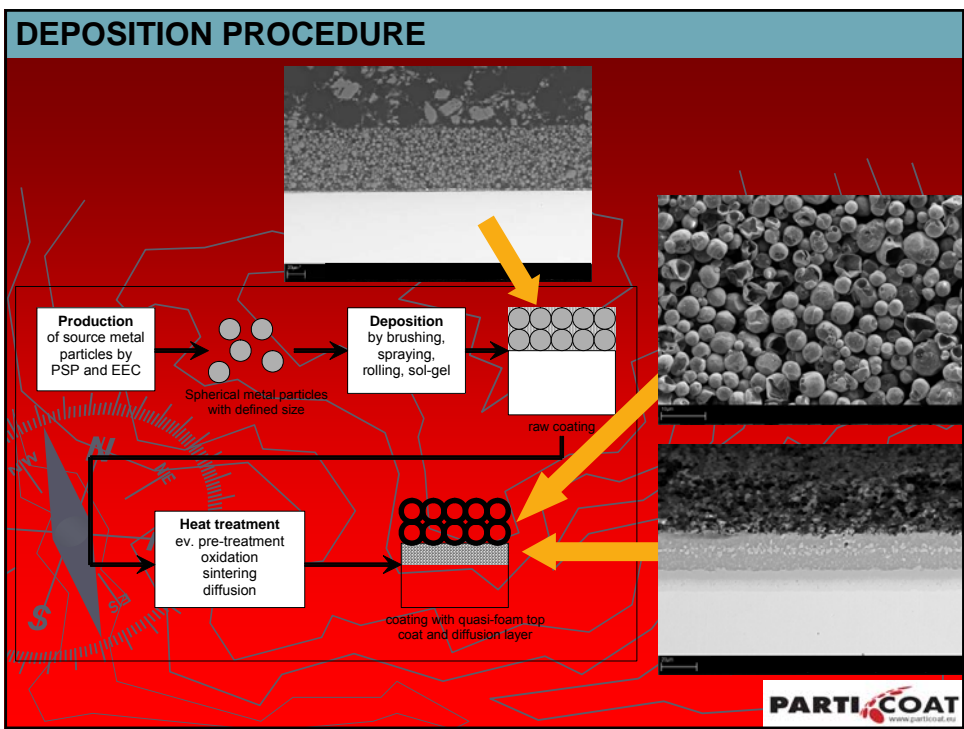
# Potential of Nano- and Micro-Scale Metal Powders

Al 31% 0-5  $\mu\text{m}$ , 69% 5-10  $\mu\text{m}$



## WORK FLOW CHART

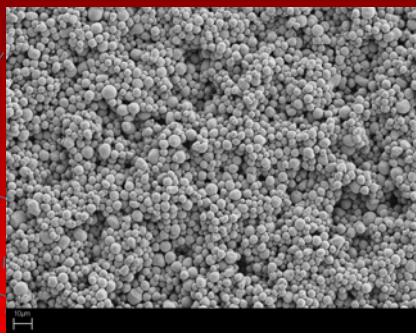




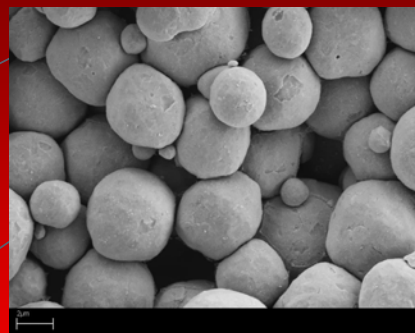
# Examples of Coatings Produced So Far

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## Binder #1 400°C



500:1

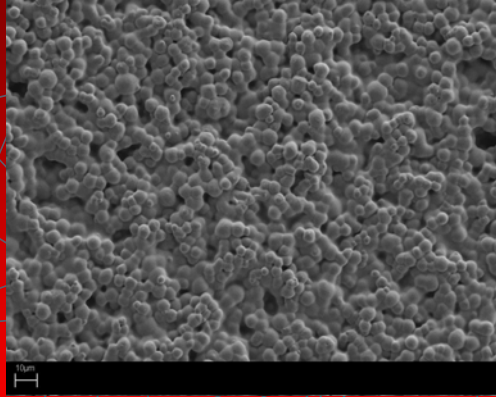


5000:1

Vaporization of the organic binder and beginning of Al particle sintering

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## Binder #1 650°C

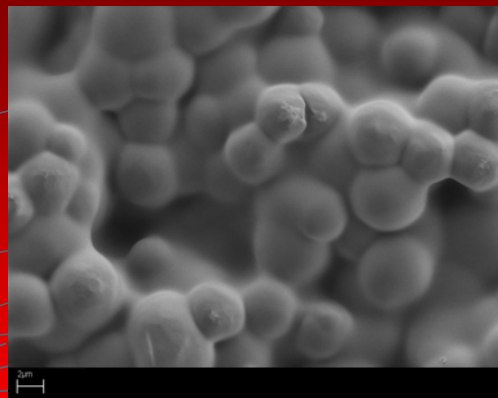


500:1

Densification of the metallic „green“ coating

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## Binder #1 650°C

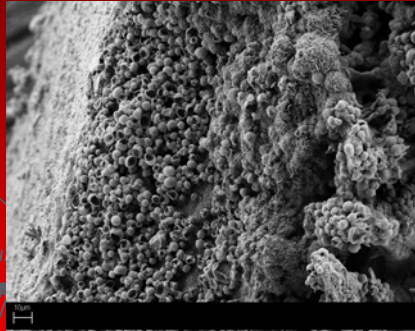


3000:1

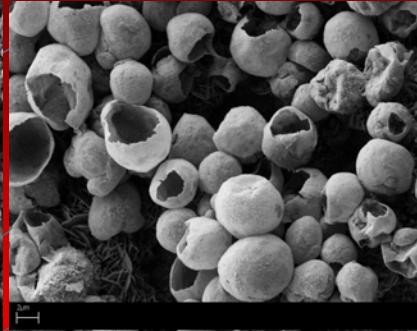
Densified aluminum „green“ coating

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# Binder #1 900°C



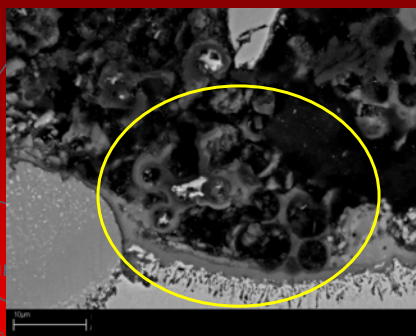
500:1



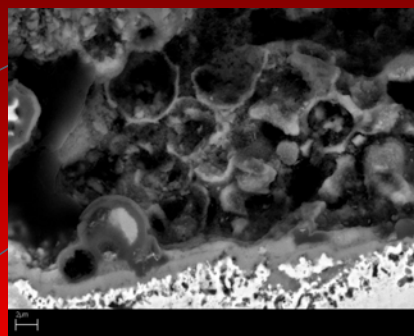
3000:1

Broken up „cross-section“ of the ceramic alumina „foam“

# Binder #1 900°C



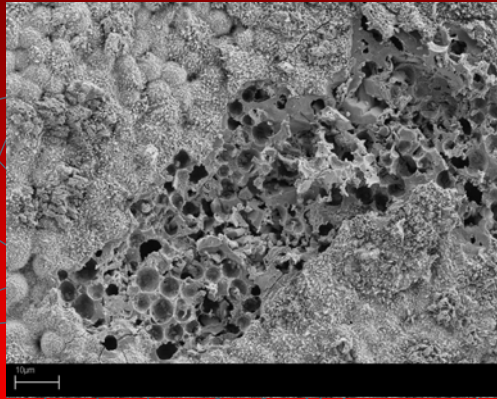
2000:1



3000:1

Substrate/foam interface

## Binder #2 900°C

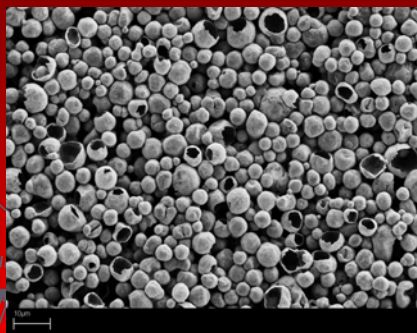


100:1

Opened-up surface of the ceramic alumina foam

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## Binder #3 650°C



1000:1

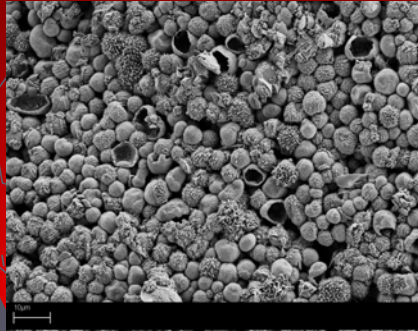


5000:1

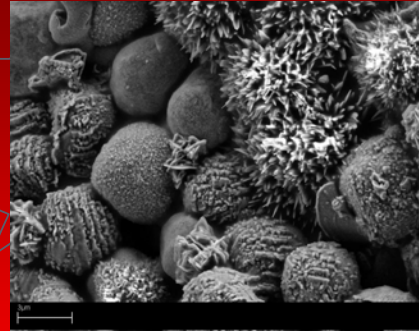
Hollow ceramic alumina spheres

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## Binder #3 900°C



1000:1

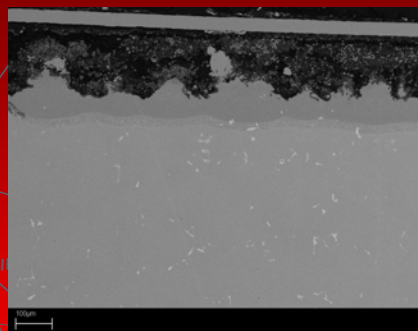


5000:1

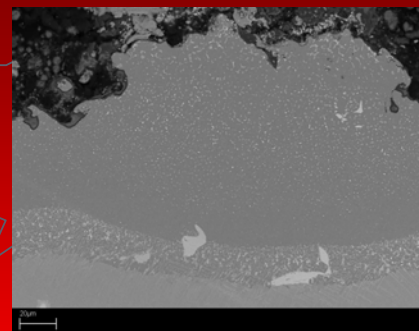
Influence of binder:

Example of reduced sintering activity and appearance of meta-stable alumina phases

## Binder #3 900°C



100:1



500:1

Possibility to influence the coating/substrate interface  
(wavy interface = keying effect)

## Summary

- ▶ PARTICOAT is developing an innovative concept for thermal barrier coatings where in one single thermal treatment step a combined bondcoat/topcoat system is being formed
- ▶ This is achieved by the use of spherical nano-/micro-scale metal particles. These serve as a reservoir for the formation of the Al rich bond coat and are converted into hollow alumina spheres by oxidation
- ▶ The top coat, in the form of the sintered hollow alumina spheres, provides a thermal barrier
- ▶ Initial results demonstrate the viability of the concept

## Properties

- ▶ Easy to apply
- ▶ Low cost
- ▶ Low application temperatures
- ▶ Possibility to form dense layers with increased mechanical compliance
- ▶ Alumina is no oxygen conductor and provides a very good barrier effect against ingress of corrosive species
- ▶ Significant potential for electrical and thermal insulation
- ▶ Al subsurface reservoir for protective alumina scale formation

# Application areas

- ▶ Gas turbines in electric power generation and aero-engines
- ▶ Abradable coatings
- ▶ Steam turbines in electric power generation
- ▶ Combustion chambers, boilers
- ▶ Steam generators, superheaters
- ▶ Waste incineration
- ▶ Fire protection of composite materials in construction
- ▶ Reformers and reactors in chemical and petrochemical industry
- ▶ Electrical insulation in arc melting furnaces