



# **INSIDE & ON TOP MATERIAL SOLUTIONS** by Fraunhofer ISC

**Pilot Plant infrastructures for modern materials and  
process development and recycling**

**NANOSPAIN 2017 Workshop  
8th March 2017, San Sebastian**

# Fraunhofer ISC Group overview



**Project Group IWKS**  
**Alzenau, Hanau**  
**Ressource strategies**  
**Recycling**  
**Substitution**



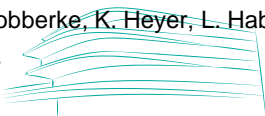
**Fraunhofer ISC**  
**Headquarters Würzburg**  
**Material development**  
**Process development**  
**Analytics**



**Project Center HTL**  
**Bayreuth**  
**Energy efficient**  
**processes**  
**High temperature**  
**materials/-composites**

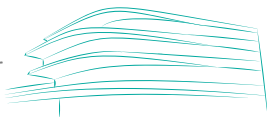
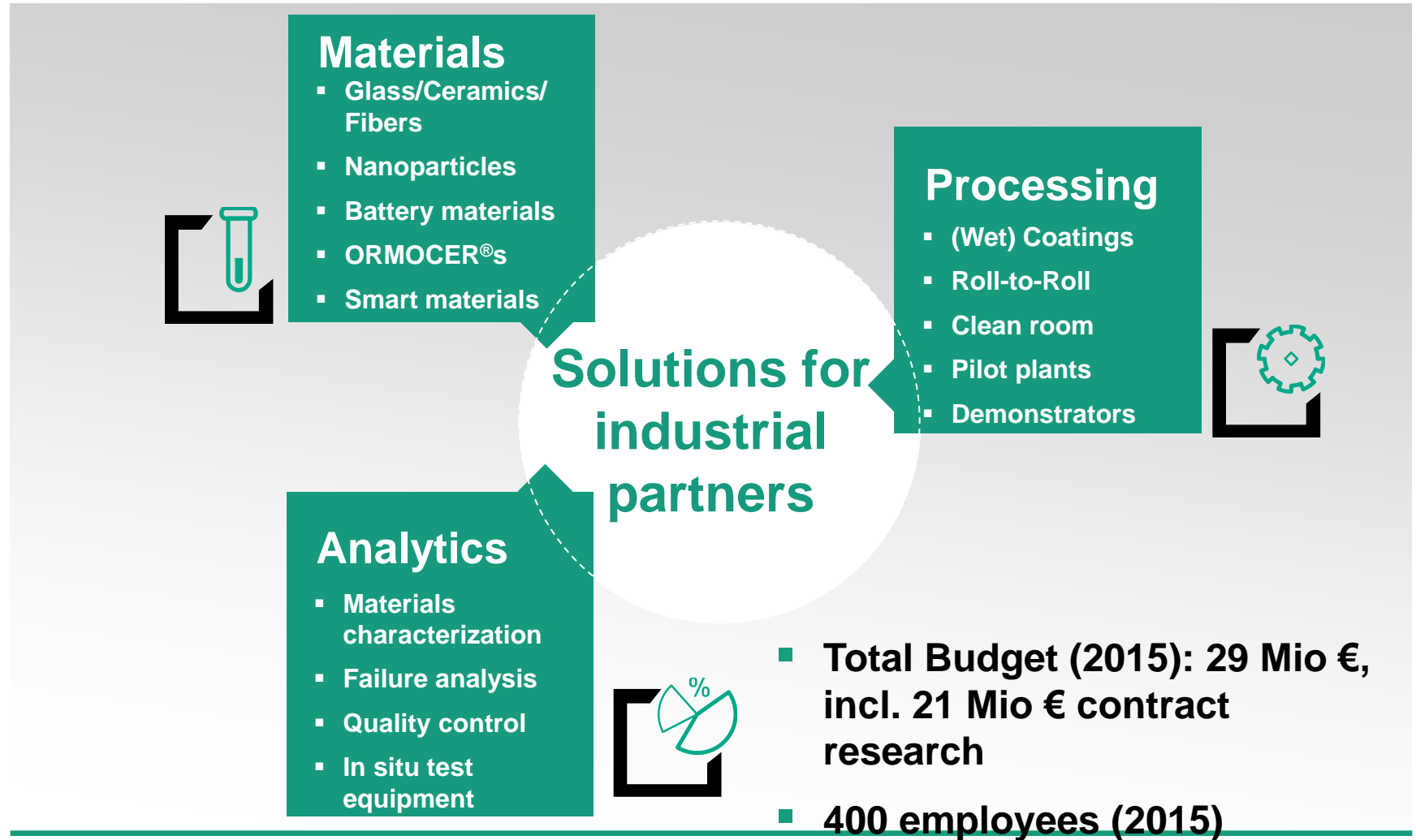
Bilder: K. Dobberke, K. Heyer, L. Haber für Fraunhofer ISC

© Fraunhofer



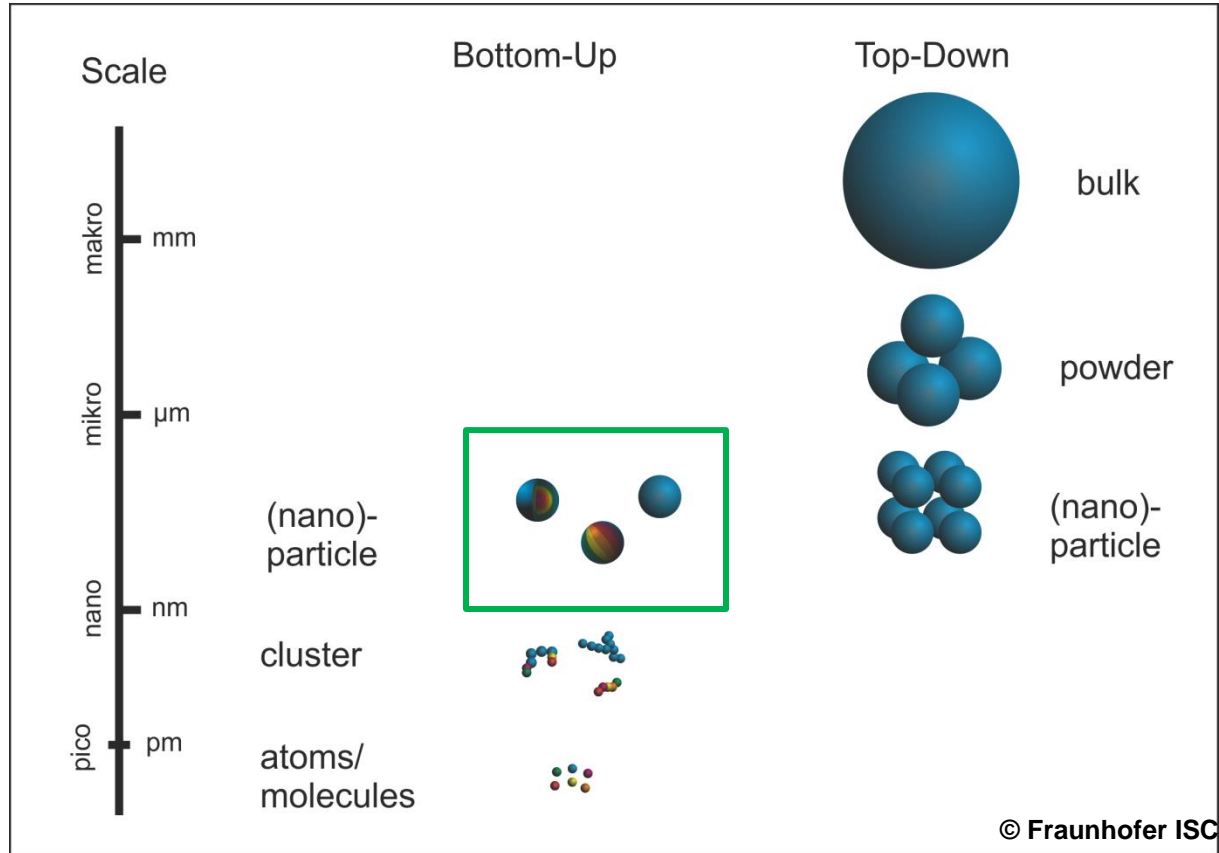
# Fraunhofer ISC

## Our core competencies



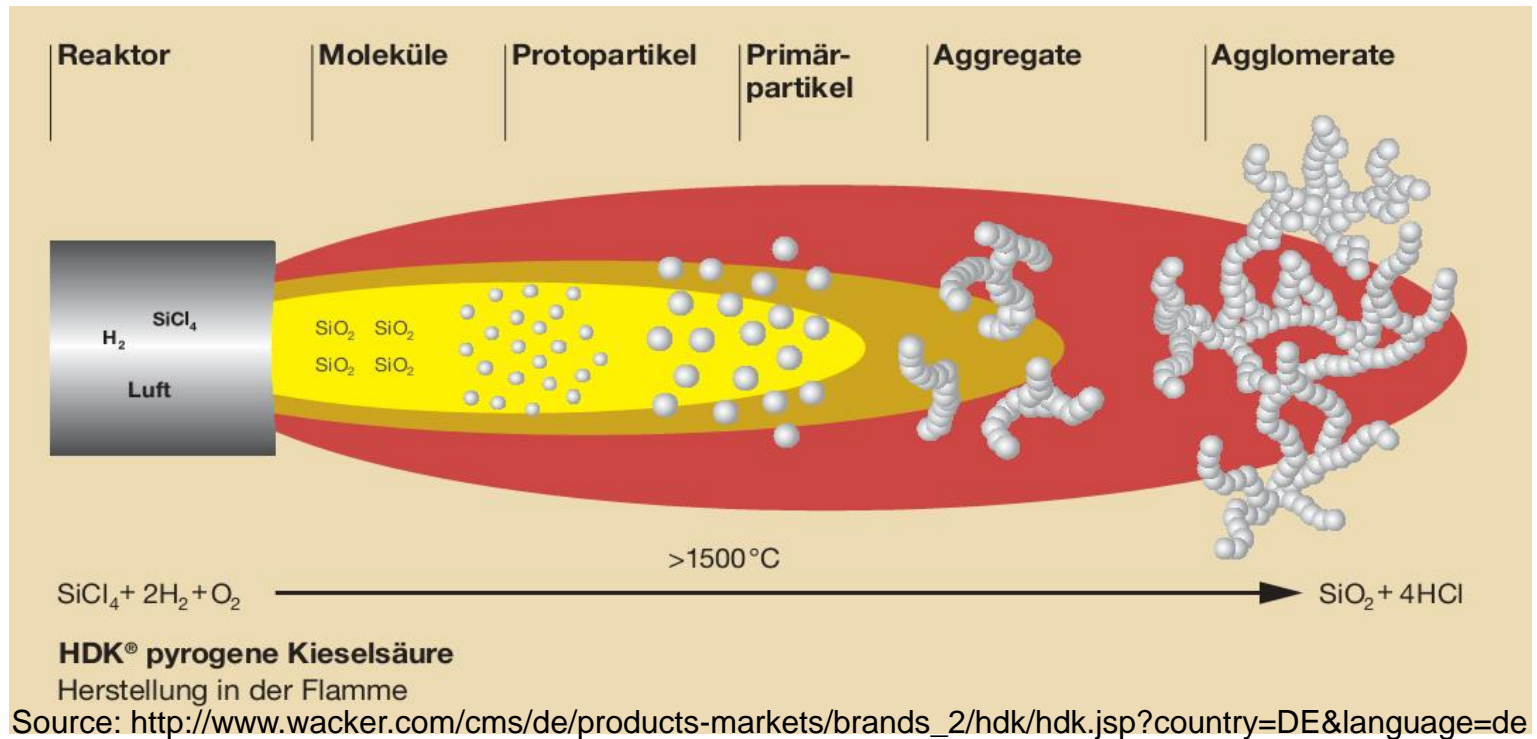
# Nanoparticle synthesis methods overview:

## Top-down versus bottom-up



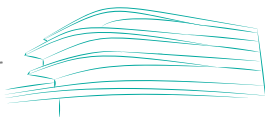
**USP of bottom-up: high complexity @ one spot**

# Bottom-up “dry synthesis”: example gas-phase synthesis



Result: primary particles are nano,

**BUT they are often obtained as “hard agglomerates”**



# Bottom-up wet chemical synthesis & processing

- Ideal dispersion: Wet chemical synthesis; creation of a sol

➡ Application

Further processing



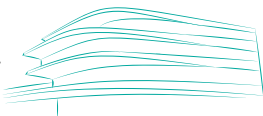
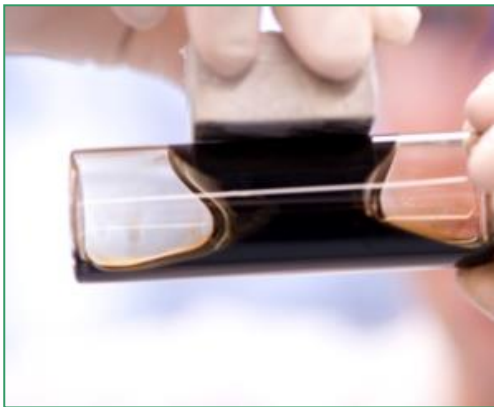
- Controlled and tailored surface functionality

➡ Application

Further processing

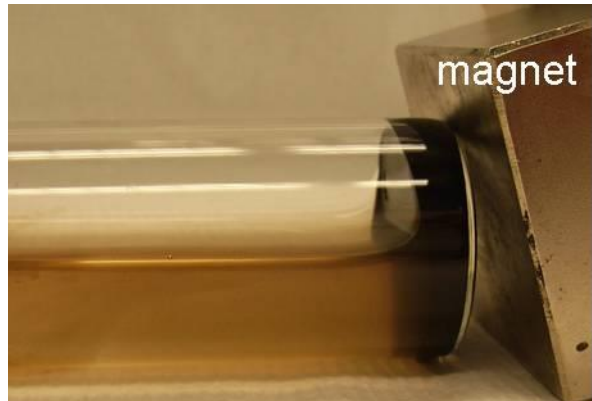


- Processing to composites:
  - Control over particle distribution in the composite
  - Often beneficial: particle accumulation at the composite surface

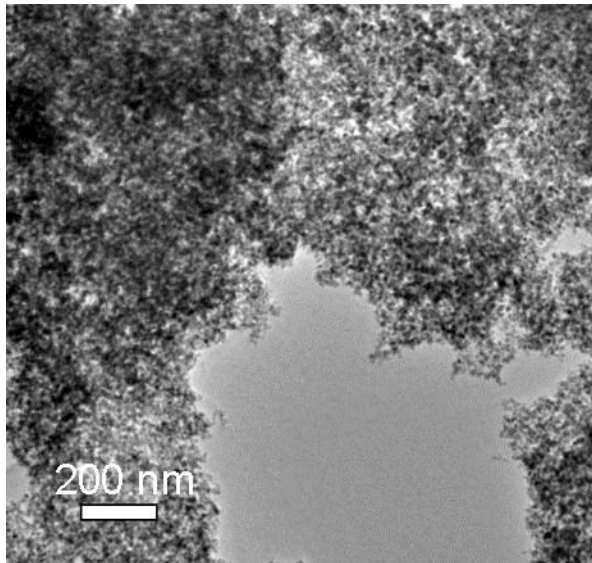




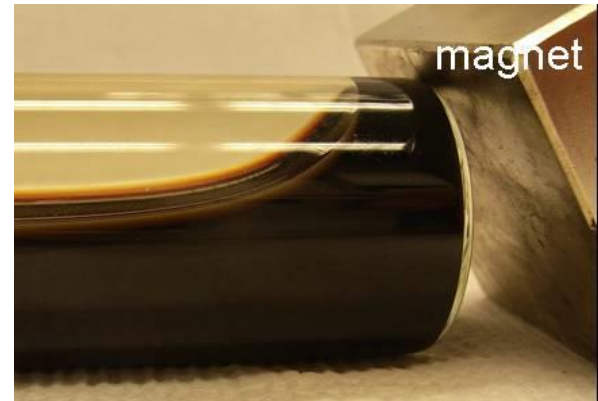
# Major advantage of wet chemistry: real nano dispersions = what makes the difference example #1



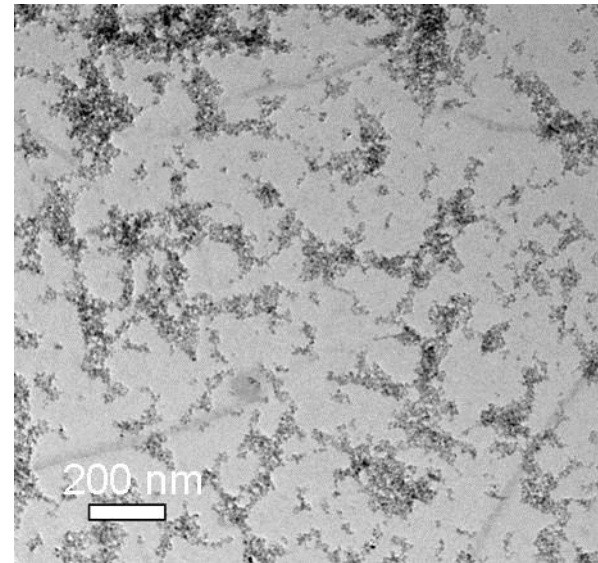
**Agglomerates**



versus



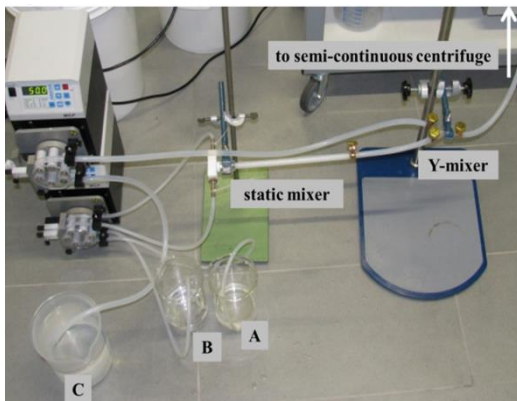
**real nano dispersion**



# Open-access pilot facility for NP synthesis „The nanoparticle kitchen“ (COPILOT)

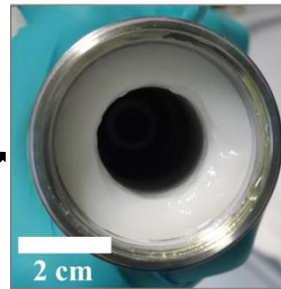


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 645993.

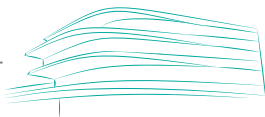
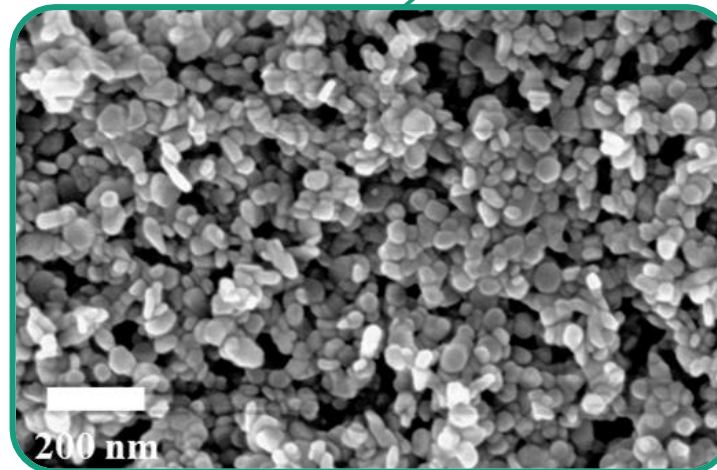
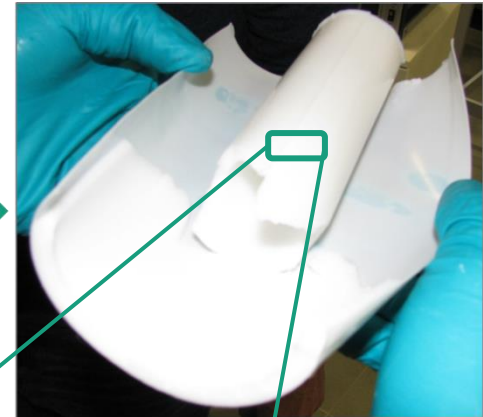




# Example: Layered double hydroxide NP “harvesting”



Harvesting LDH



# THE NANOPARTICLE KITCHEN

Have you ever thought of how your nanoparticles could be upscaled or how nanoparticles could be added to increase your product performance? With our extensive pilot line equipment we can support you in synthesis, modification as well as dispersion of nanoparticles in different upscaling stages.

Our laboratory works like a kitchen – you come to us with a specific menu or taste in mind. We provide the cooking ingredients, the pans and stove, as well as the internationally experienced cooks. You are welcome as well, if you want to upgrade or functionalize your own »cooking« materials.

## Our Special Equipment

- Synthesis reactor (up to 100 liter batches)
- Continuous ultrasound reactor
- Semi-continuous centrifuge
- Spray-drying facilities
- Continuous flow globe mill
- Molecular vaporizer
- Magnetic drum separator
- Encapsulation device
- Ultrafiltration
- Glas autoclave
- Fluidised bed reactor
- ... and many more

## Our Special Ingredients

We offer materials development and custom manufacturing of small particles matching your demands, for instance:

- Magnetic Particles
- Hollow Particles
- Silica Particles
- Layered Particles
- Titanium, Zirconium, Zinc and Perovskite Oxide Particles

Interested in the nanoparticle kitchen taste? Contact us!

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[www.isc.fraunhofer.de](http://www.isc.fraunhofer.de)

## SPECIAL EQUIPMENT...



## CHEFS COOKING...



## ...WITH SPECIAL INGREDIENTS



From the first lessons learned:  
**Business:**  
 We do *not* “sell” nanoparticles,  
 we sell hands-on consulting for material solutions

**USP:**  
**Facilities**  
**COMBINED WITH**  
**know-how**

→ combination needs to be offered to customers to bring nano to success



# Roll-to-Roll Coating Plant @ Fraunhofer ISC

- ISO 8 cleanroom
- 500 mm working width
- Job-shop coating

© Photo K. Dobberke for Fraunhofer ISC

[illegible]

- Fully modular Click&Coat system (COATEMA)
- Can be assembled according to the needs and fitted subsequently
- Standard slot-die coating – other application systems upon request

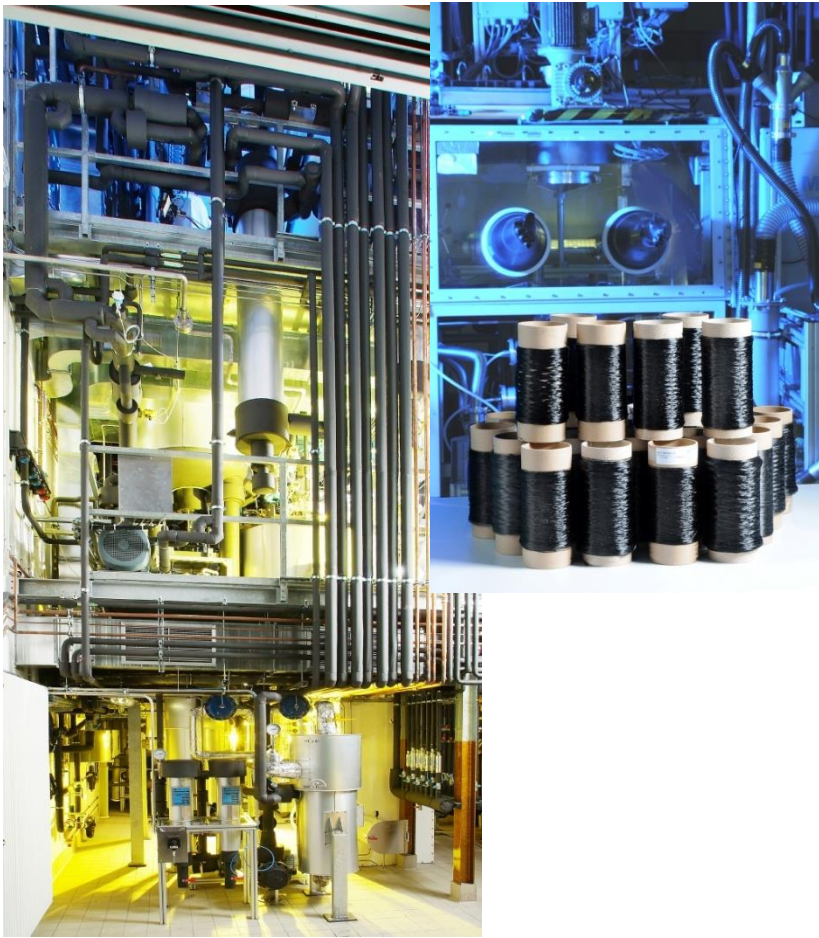


# High-Throughput-Glass-Screening

A woman in a white lab coat and red scarf is operating a high-throughput glass screening system. The system is a complex assembly of metal frames, glass enclosures, and a robotic arm. The robotic arm is orange and is positioned over a series of glass wells. The system is designed for high-throughput screening, with multiple glass wells and a robotic arm that can handle multiple samples simultaneously. The woman is standing at a control station with a computer monitor and keyboard, monitoring the process. The background shows a laboratory setting with various equipment and materials.



# Ceramic/ Inorganic Fibers



**Preparation of spinning mass**



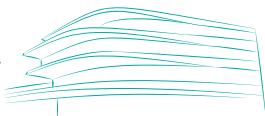
**Melt spinning & dry spinning  
1 – 1000 filaments, continuous fiber**



**Fiber spinning towers:  
temperature field, atmosphere (  
2 ppm H<sub>2</sub>O, < 5 ppm O<sub>2</sub>) and gas  
flow adjustable**



**Continuous pyrolysis and sintering  
with inert gas**



# Application Center “Textile Fiber Ceramics“

## Aim

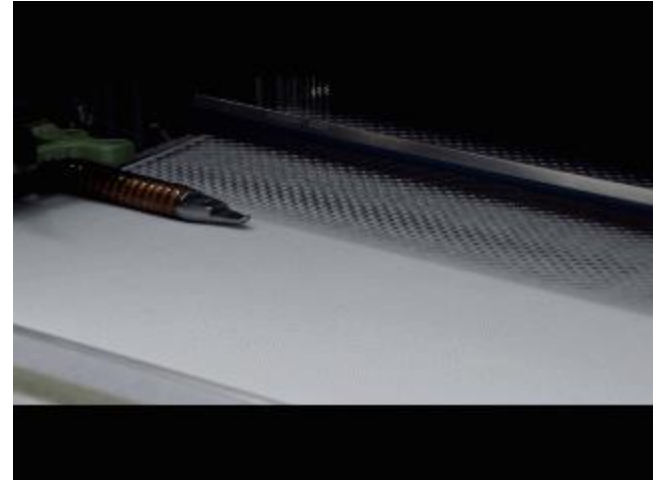
- Production of textile 2D and 3D structures of ceramic and carbon fibers
- Load-conforming fiber alignment
- Control of suitability of ceramic fibers for textile manufacturing

## Technologies

- Weaving, braiding, knitting and warp knitting as well as fleece production

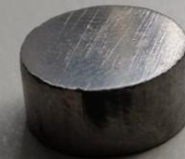
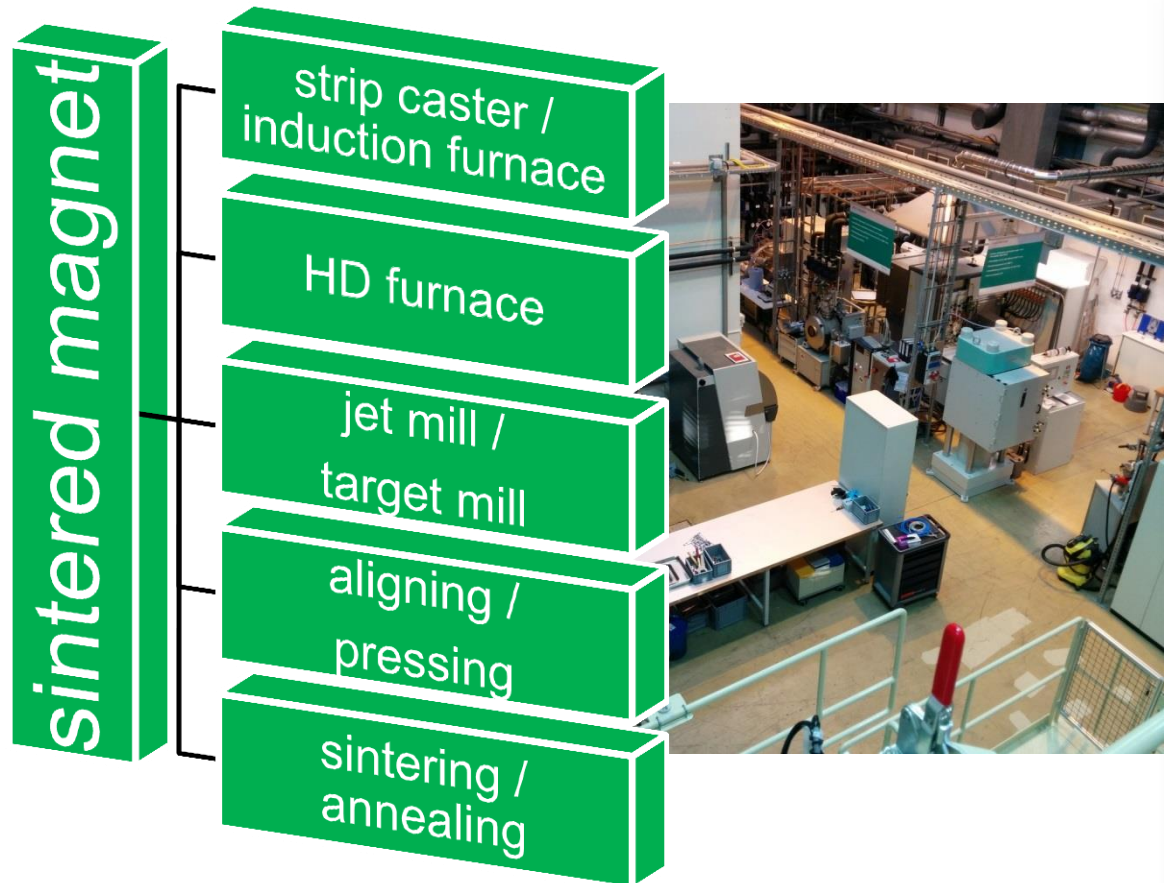
## Project dates

- Head: Prof. F. Ficker
- Funding: 2.5 Mio. €
- Period: June 2014 – May 2019



# Pilot Plant for Sintered Magnet Production

## Magnets with much less Rare Earth Metals





# RECYCLING PILOT PLANTS: INNOVATIVE TECHNOLOGIES

## SOME EXAMPLES OF MODERN PRODUCTS



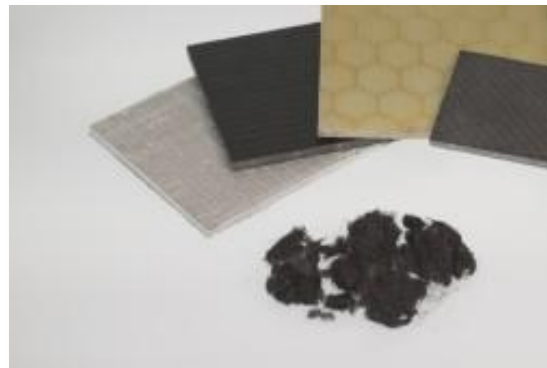
**Lithium-Ion  
Cells**



**LEDs**



**PV**

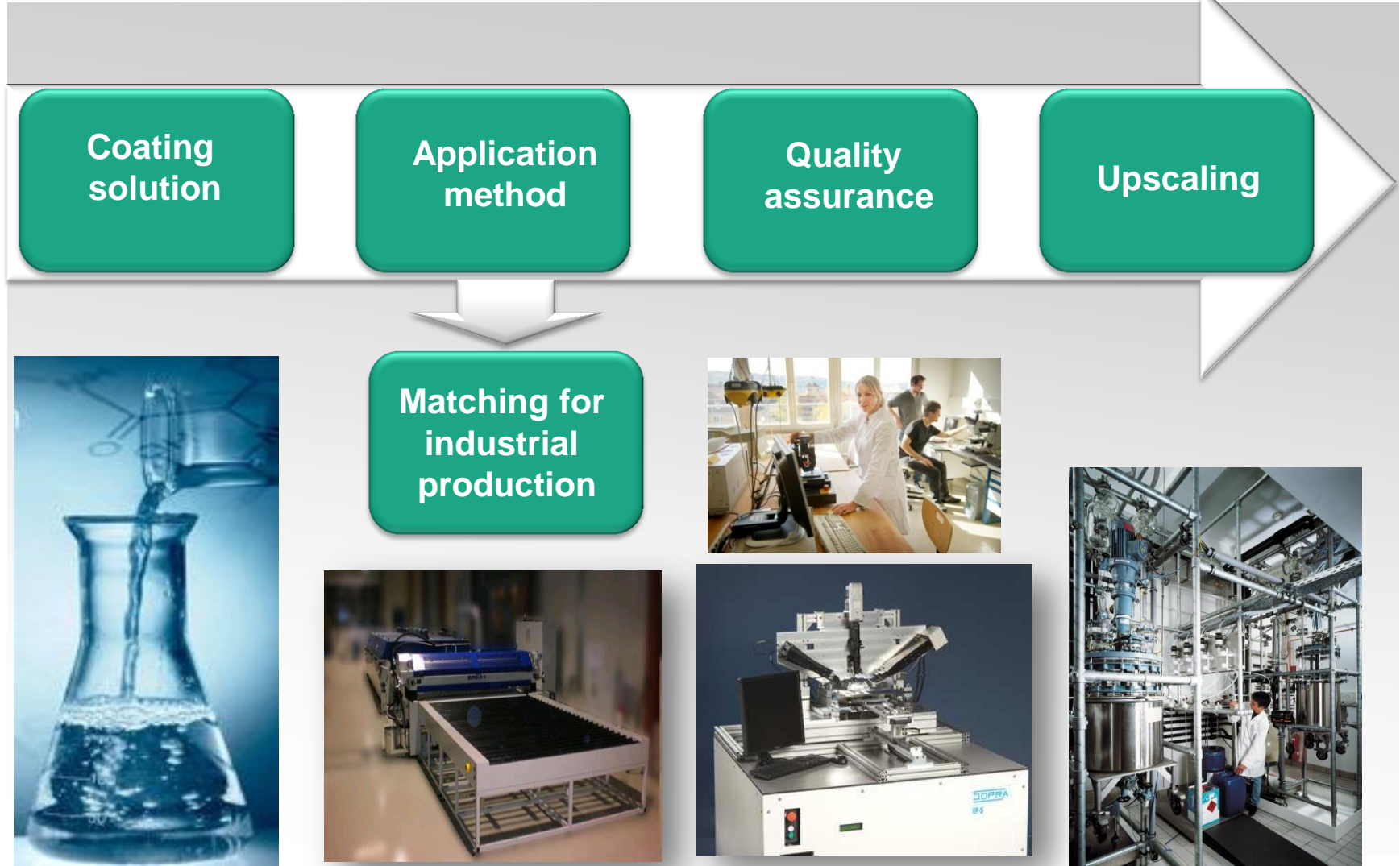


**Fiber Composites**



**iPhone 4s**

# Entire product development value chain to be covered







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