

14.02.2019

Successful R&I in Europe 2019 - 10th European Networking Event

Particle Process Technology: From the Synthesis of Highly Specific Nanomaterials on the Pilot Plant Scale to the Characterization of particles

Tim Hülser, Division Particle Process Technology and Characterization

IUTA - Institut für Energie- und Umwelttechnik e.V.
Institute of Energy and Environmental Technology

An-Institut der
UNIVERSITÄT
DUISBURG
ESSEN



JRF
MITGLIED Johannes-Rau-
DER Forschungsgemeinschaft



Af Mitglied



- Founded 1989 as an Co-Institute of University Universität Duisburg-Essen
- ~ 130 scientific and technical co-workers
- Non-profit research organization
- Energy and Environmental technology
- Application - und fundamental research orientated projects in Colaboration with
 - Universities, Research organizations (JRF)
 - Public and Regulating authorities
 - Industrial partners
- Focus on SME
- Direct utilization of research results
- Turnover 8-10 Million €
- Pilot plant area: 5.200 m²

- NILU, Norway
- IOM, Edinburg, UK
- Kings College London, London, UK
- NPL, Teddington, UK
- Uni Paris, France
- CEA, Grenobel, France
- ISSeP, Liege, Belgium
- Uni Utrecht, NL
- RIVM, Utrecht, NL
- TNO, Eindhoven, NL
- ECN, Petten, NL
- EMPA, Zürich, Suisse
- PSI, Villigen, Suisse
- CSIC, Barcelona, Spain
- Uni Athen, Greece
- JRC, Ispra, Italy
- ENEA, Rom, Italy





Expertise

- Process engineering on pre industrial scale
- Chemical and physical Analytics

Topics

- Particles
- Gases
- Toxins



Methods

- Identify Problems
- Analyze and define problems
- Fundamental Research
- Implementation concept
- Transfer of results

Aerosole & Particle Technology

- Nano particles & Fine Dust
- Synthesis methods
- Work safety
- Environmental impact

Air purification & Gas process Technology

- Sorption processes
- Filtration processes
- CFD-simulations
- numerical particle distribution

Ressources & Toxines

- Identification
- Separation
- Process analysis
- Process development

Analytics & Measurement Technology

- Field measurements
- Trace element analytics
- Effect analytics
- Measurement device development



Nanoparticle synthesis on the pilot-plant scale



- Nanoparticles available on the kg/h scale
- Combination of three different reactors concepts
- Laser-based in-situ measurements
- Detailed simulation of reactive flows in progress

Nanoparticle synthesis on the pilot-plant scale



Plasma reactor

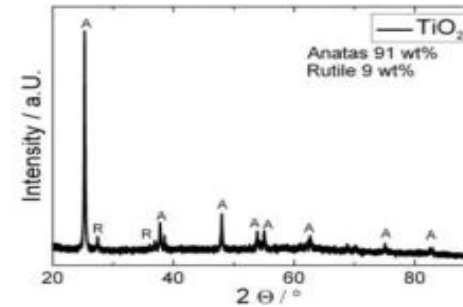
Flame reactor

Hot wall reactor

- Nanoparticles available on the kg/h scale
- Combination of three different reactors concepts
- Laser-based in-situ measurements
- Detailed simulation of reactive flows in progress

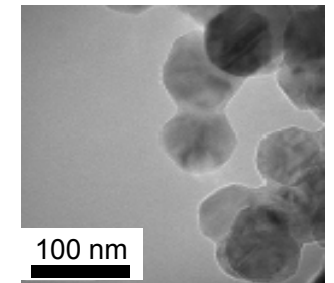
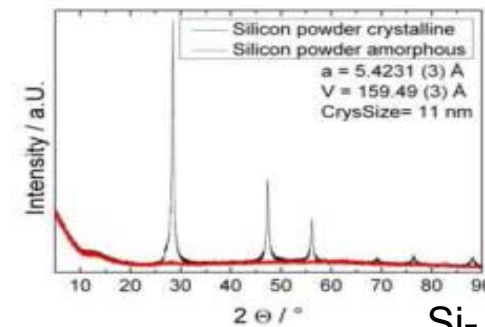
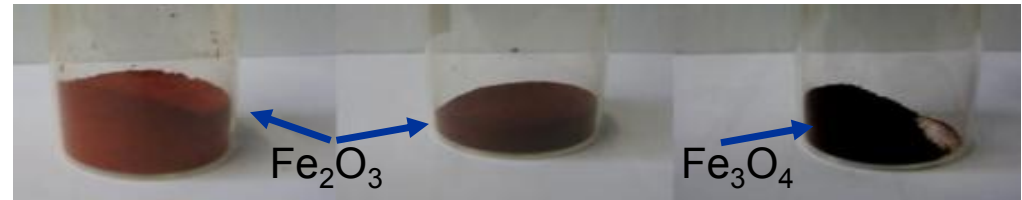
Oxides

- TiO_2
- Specific Iron oxides
- SiO_2
- ZnO



Non- Oxides & Composites

- Si, doped and un-doped
- Si @ C, SiC
- Si doped SiO_2 (Si Quantum dots)
- Si / Ge
- FeSi_2
- Core Shell Systems ($\text{Fe@Fe}_2\text{O}_3$)



Si- Nanoparticles

Material available at Strem.com

I. Fuel cells:

Develop electrodes with long-term stability with low precious metal load by better understanding aging mechanisms

II. Catalysts for energy technology:

Develop immobilized, functional nanoparticles for photo-catalytic water dissociation, improving photo-catalysis

III. Battery technology:

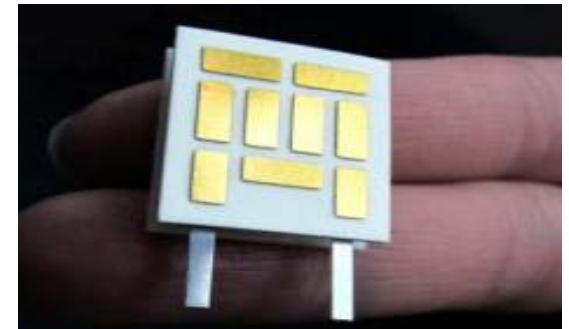
Develop anode materials with high storage capacity of >1500 mAh/g based on Si / C nanocomposites

IV. Photovoltaics:

Reduce the number of process steps and processing temperature of Si-based photovoltaics using highly doped Si nanoparticles and laser sintering

V. Thermoelectric generators:

Develop thermoelectric materials based on Si and SiX nanocomposites. Unlike the Pb, Te, and Sb compounds typically used so far, Si-based systems are non-toxic and uses abundant raw materials



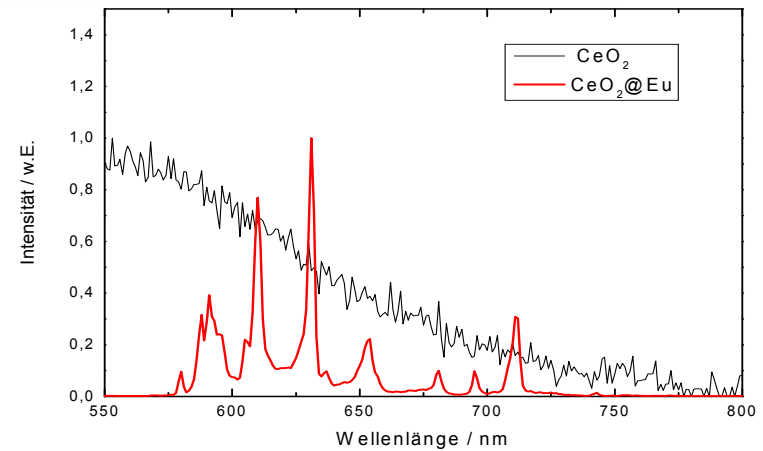
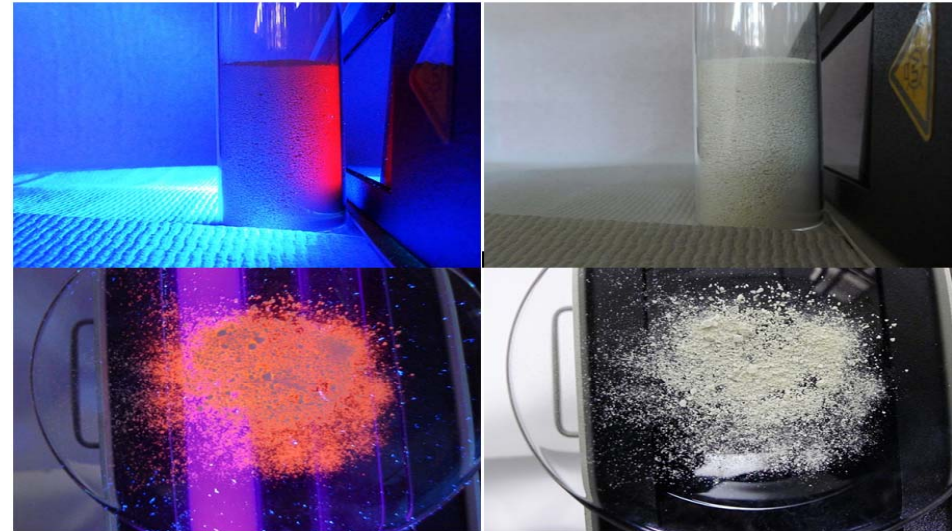
Silicon based thermoelectric generator made in collaboration of IUTA, NST, SLV (Duisburg)

Powder

- BET
- FTIR
- Impedance measurement
- SEM
- Luminescence Analysis

Liquids

- DLS
- Milling
- Sonication
- SEM



Functionalization & Dispersion

Surface modification of synt. particles is the key for the production of dispersions

SiO₂ NPs
 $d_p \sim 28$ nm

Gas phase In liquid

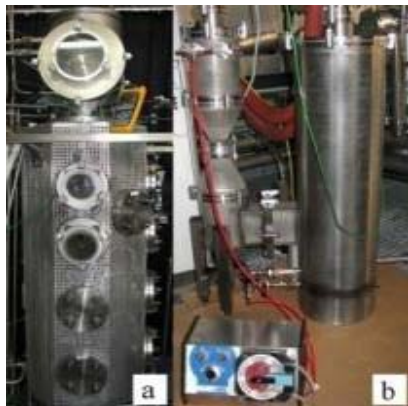
28 nm

Silanization Coating

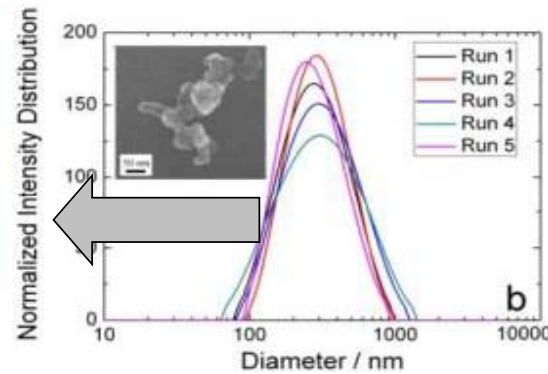
Glas-Substrat

Hydrophobic Surface

In-situ separation of nanoparticles from the reactors



a:
Flame
Reactor
b:
Venturi
scrubber
(pilot plant
scale)



a:
Scrubbed TiO₂ nano
particles from FLR in
liquid (stable for several
days)
b:
DLS measurement from
suspension and REM
image

Calls/Experience in international projects



- **Sustainable Nano-Fabrication (CSA) ID: DT-NMBP-12-2019, Deadline 03.09.2019 Call name: FOUNDATIONS FOR TOMORROW'S INDUSTRY | Call ID: H2020-NMBP-TO-IND-2018-2020**

- Cover research and new standards for functional nanoparticles, nanomaterials, components, devices and processes
- Establish common approaches for measurements and characterisation applied for nanomaterials by design
- Cover sustainability in terms of environment, life-cycle analysis;

- **IUTA:**

running:

- NanoFASE, 4 years, 2015-2019 (H2020)
- BIORIMA, 4 years, 2017-2021 (H2020)

finished:

- FutureNanoNeeds, 4 years, 2014-2017 (FP7)
- AirMonTech, 4 years, 2010-2014
- Nanodevice, 4 years, 2008-2012
- NanoImpactNet, 4 years, 2008-2012
- EnerGEO, 4 years, 2009-2013
- NETZ- Nanomaterials for Energy Applications, 4 years, 2009-2013

- **New partners searched:**

- Research partners (industry and university) in the field of functional nanomaterials synthesis, processing of nanomaterials and applications
- Application partners (companies), that are interested to bring our developments to the market

- **Contact us at: www.iuta.de**



EUROPÄISCHE UNION
Investition in unsere Zukunft
Europäischer Fonds
für regionale Entwicklung

Ziel2.NRW

Regionale Wettbewerbsfähigkeit und Beschäftigung

Ministerium für
Kultur und Wissenschaft
des Landes Nordrhein-Westfalen

