About OMICS Group

OMICS Group International is an amalgamation of Open Access publications and worldwide international science conferences and events. Established in the year 2007 with the sole aim of making the information on Sciences and technology 'Open Access', OMICS Group publishes 400 online open access scholarly journals in all aspects of Science, Engineering, Management and Technology journals. OMICS Group has been instrumental in taking the knowledge on Science & technology to the doorsteps of ordinary men and women. Research Scholars, Students, Libraries, Educational Institutions, Research centers and the industry are main stakeholders that benefitted greatly from this knowledge dissemination. OMICS Group also organizes 300 International conferences annually across the globe, where knowledge transfer takes place through debates, round table discussions, poster presentations, workshops, symposia and exhibitions.

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About OMICS Group Conferences

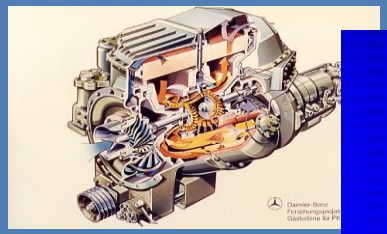
OMICS Group International is a pioneer and leading science event organizer, which publishes around 400 open access journals and conducts over 300 Medical, Clinical, Engineering, Life Sciences, Pharma scientific conferences all over the globe annually with the support of more than 1000 scientific associations and 30,000 editorial board members and 3.5 million followers to its credit.

OMICS Group has organized 500 conferences, workshops and national symposiums across the major cities including San Francisco, Las Vegas, San Antonio, Omaha, Orlando, Raleigh, Santa Clara, Chicago, Philadelphia, Baltimore, United Kingdom, Valencia, Dubai, Beijing, Hyderabad, Bengaluru and Mumbai.

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Smart advanced ceramic materials for energy and environmental technology
Alexander Michaelis, Fraunhofer IKTS

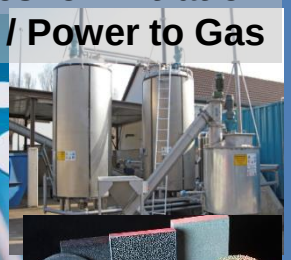
Ceramics for combustion engines and turbines





Membranes for Filtration Oxyfuel / Power to Gas





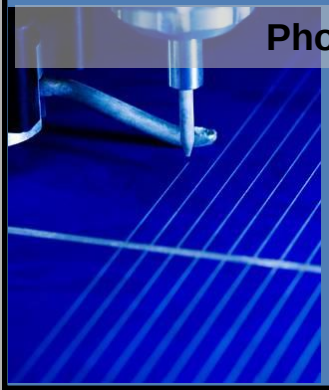


Fuel Cells

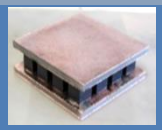


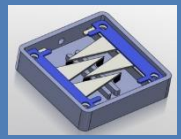


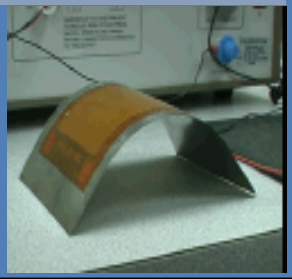
Photovoltaics



Energy Harvesting (Piezoceramics, TEG)



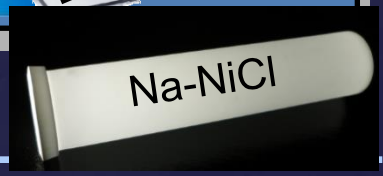




Storage Technology



- Li-Battery
- Supercup
- Na-NiCl
- SOEC - (Electrolysis)



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- Information and Communication Technology
- Life Sciences
- Microelectronics
- Light & Surfaces
- Production
- **Materials and Components – MATERIALS**
- Defense and Security

66 Institutes and independent research units

More than 24.000 staff

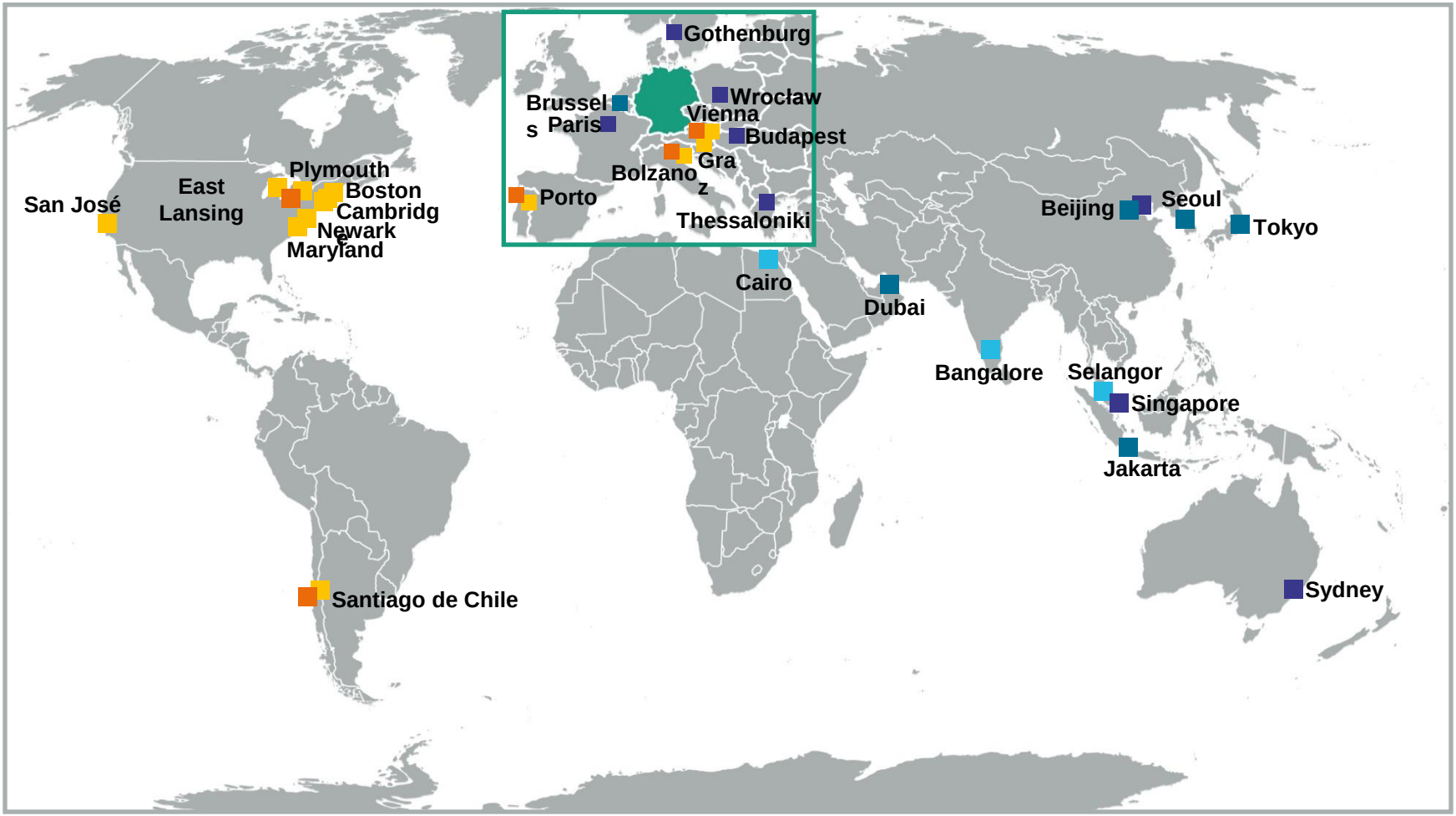
2,2 Bill. € Budget



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Subsidiary | Center | Project Center / Strategic Cooperation

Representative Office | Senior Advisor

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Cerame-Unie The European Ceramic Industry Association

Fraunhofer IKTS

Fraunhofer Institute of Ceramic Technologies and Systems: IKTS

Mio €

Staff: 650





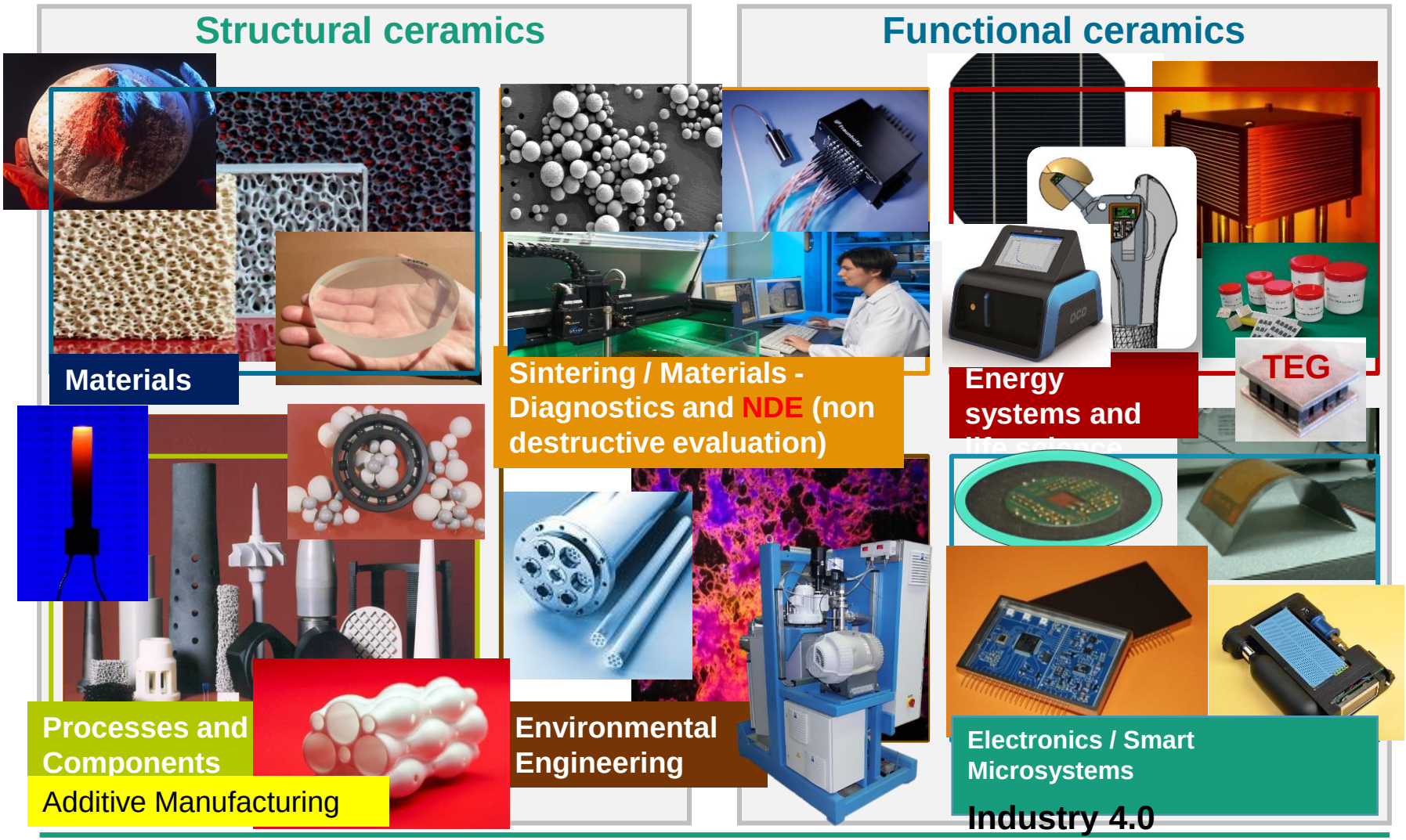


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Smart advanced ceramic materials energy and environmental technology

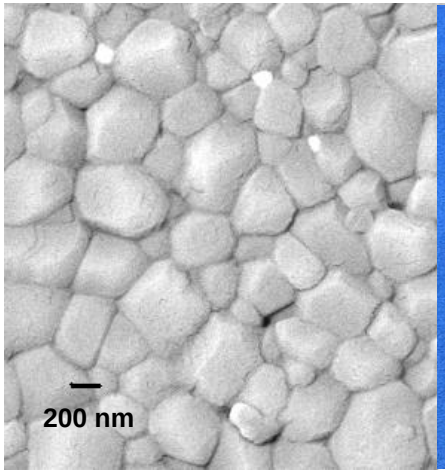
Alexander Michaelis
Fraunhofer Institute of Ceramic Technologies and Systems IKTS



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Fraunhofer IKTS

High Performance Aluminium and Zirconium Oxide Ceramics for Medical and Sensor Applications

- Optimized microstructure (uniform sub-micrometer grains, reinforcement with secondary ceramic phase, enhanced density)
- Improved mechanical properties (flexural strength, fracture toughness, micro-hardness)



REM photograph of an etched Al_2O_3 ceramic surface



Surface toughened Al_2O_3 joint implant



High dense Al_2O_3 pressure sensor membranes



Ceramic tooth crown (ZrO_2)

© Fraunhofer

Reaching physical limits

ARMY RESEARCH LABORATORY ARL

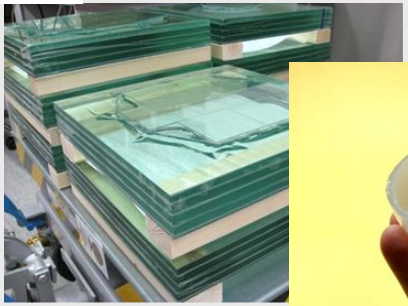
Evaluation of IKTS Transparent Polycrystalline Magnesium Aluminate Spinel ($MgAl_2O_4$) for Armor and Infrared Dome/Window Applications

by James W. McCauley and Parimal Patel

ARL-SR-262 2009 - March 2013









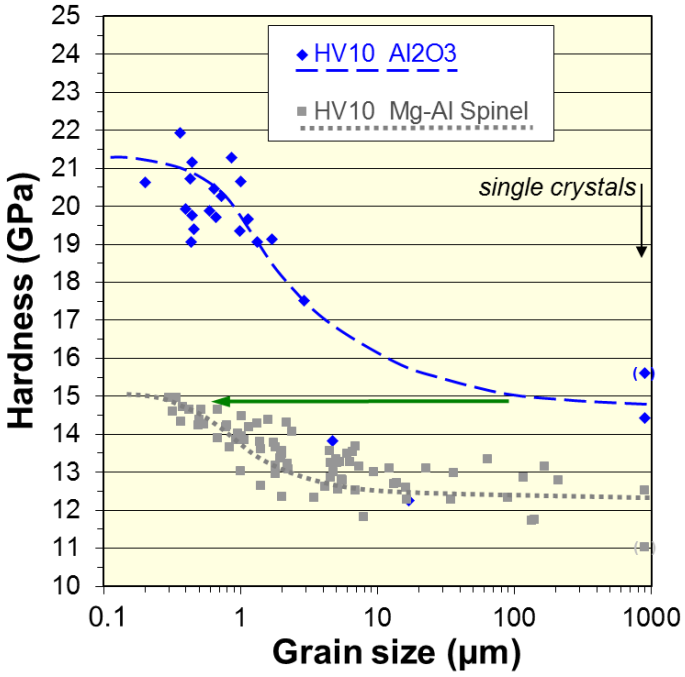
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Fraunhofer IKTS
Polycrystalline Ceramic


Source: Future Technologies
Shen Ye

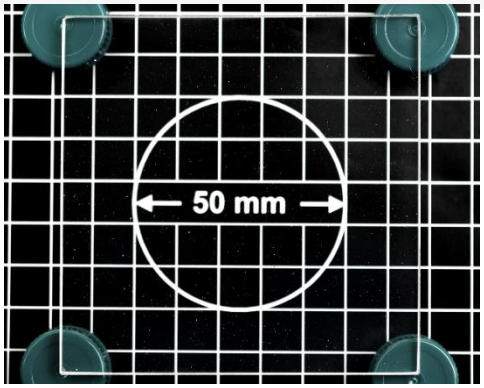


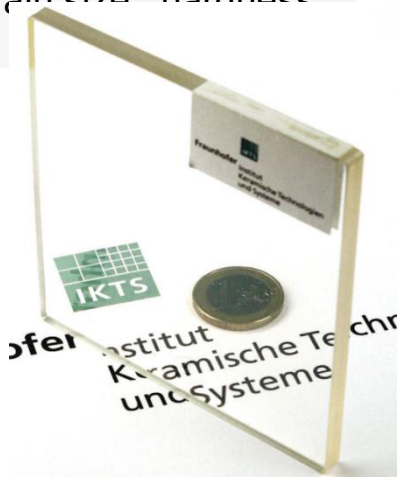
- Very hard (equivalent to sapphire) → scratch resistant
- Excellent in-line transparency (at any thickness, any background)



Example (by IKTS): Real in-line **transmission ~83%** (at 4 mm thickness)

Discs in photos: 4 mm thick, 0.6 µm grain size, hardness HV10 ~ 14.5 GPa





(A. Krell et al., Int. J. Appl. Ceram. Technol. 2011, 1108-1114; Opt. Mater. 2014, 61-74)

ceramic: scratchproof as sapphire, but not as prone to cracks

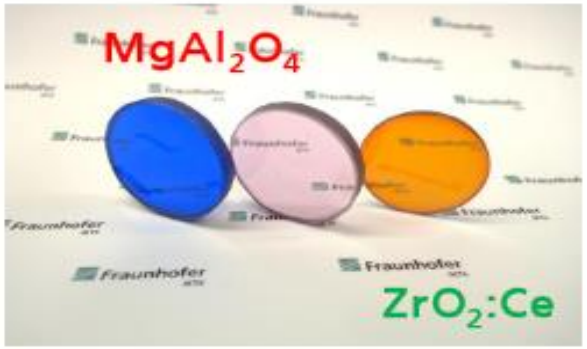
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- IKTS sintered transparent ceramics outperforms sapphire !!
- ceramics can be manufactured near-net-shape
- Minimum finishing (grinding, cutting) effort

} cost advantage

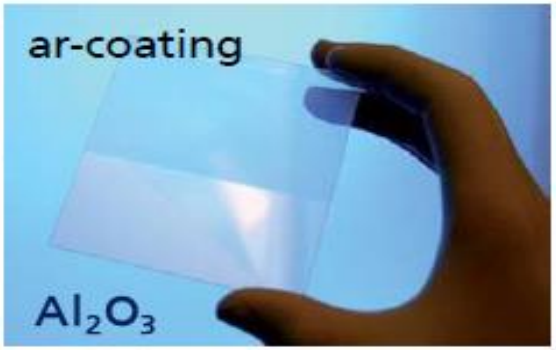
- IKTS is world leading in optical / mechanical quality (own IP)









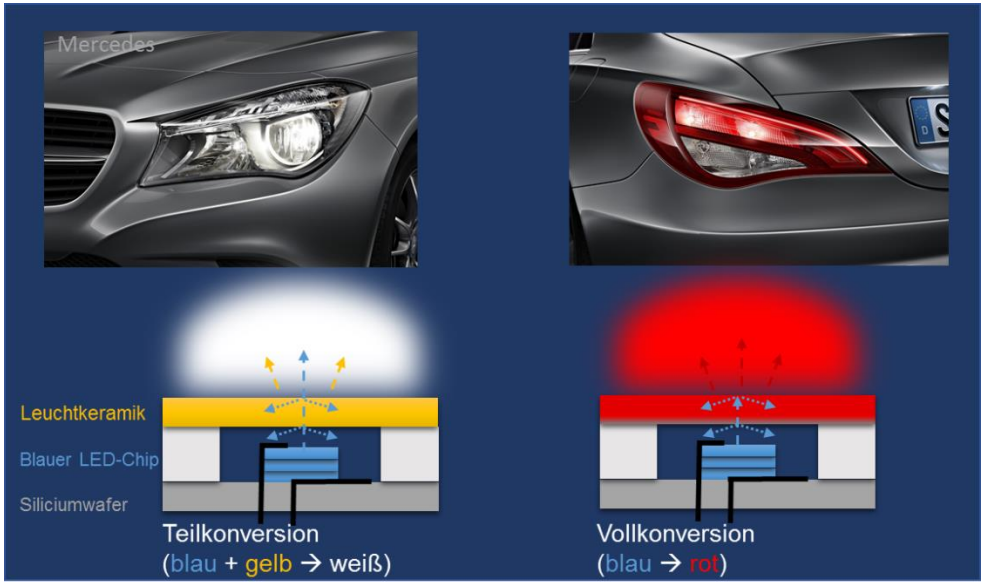


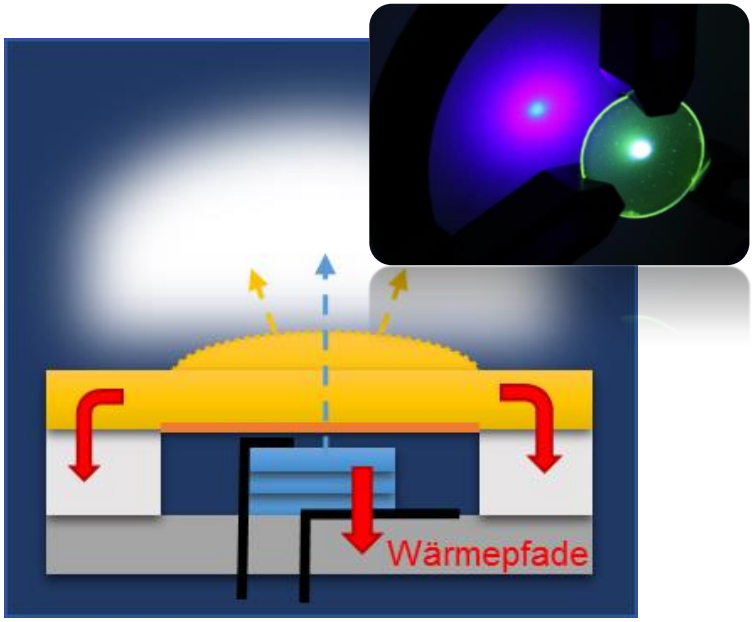


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Fraunhofer IKTS

Smart transparent ceramics in the Int. Year of Light
Ceramic Coverters for laser-LED- head lightning





- Improved life time
- Improved luminosity and heat dissipation
- Improved down conversion
- Different light colors
- Lower production cost

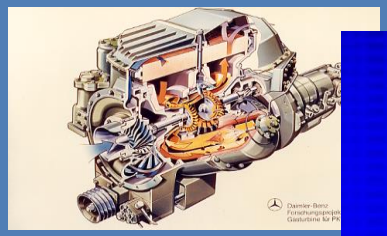


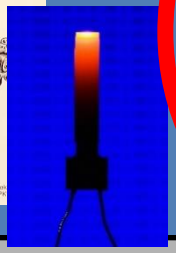
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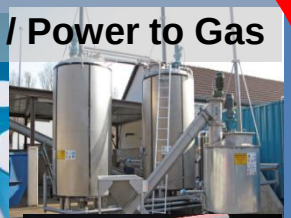
Ceramics for combustion engines and turbines





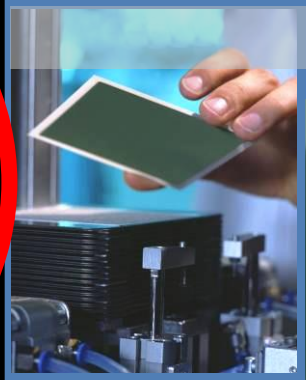
Membranes for Filtration Oxyfuel / Power to Gas







Fuel Cells

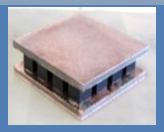


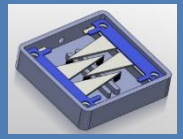


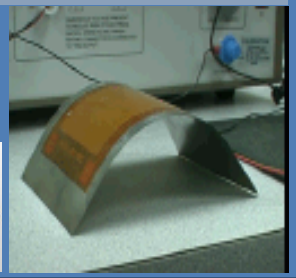
Photovoltaics



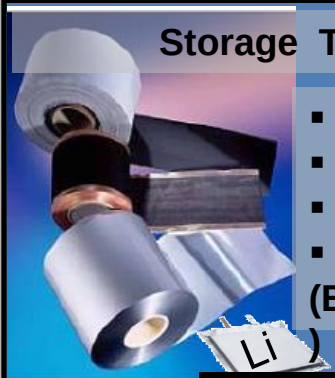
Energy Harvesting (Piezoceramics, TEG)



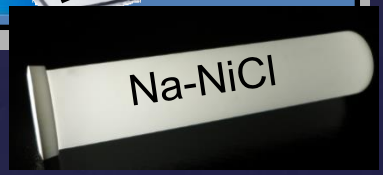




Storage Technology



- Li-Battery
- Supercup
- Na-NiCl
- SOEC - (Electrolysis)



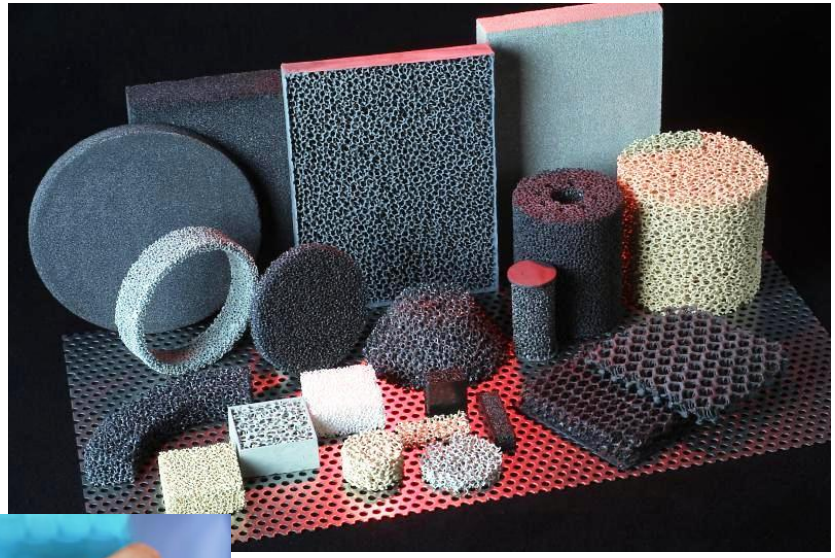
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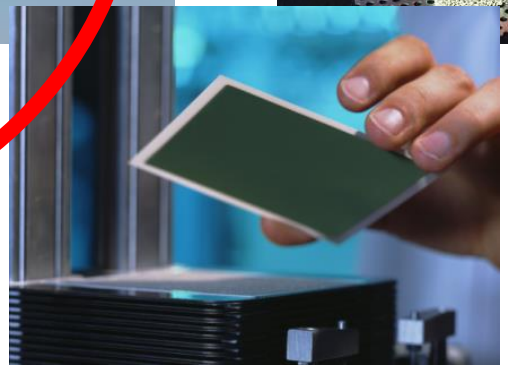
Design of pores in inorganic membranes for efficient separation of liquids and gases



Ceramic Membranes



Ceramic Foams

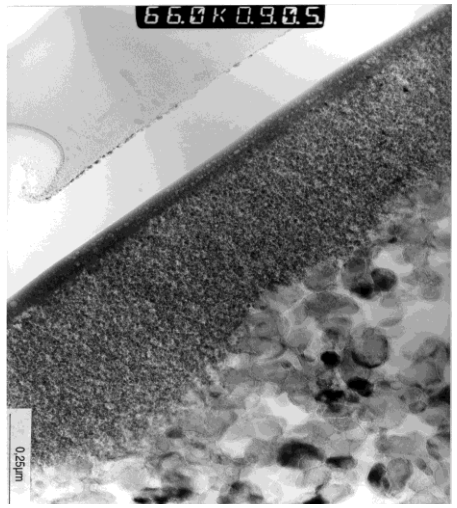


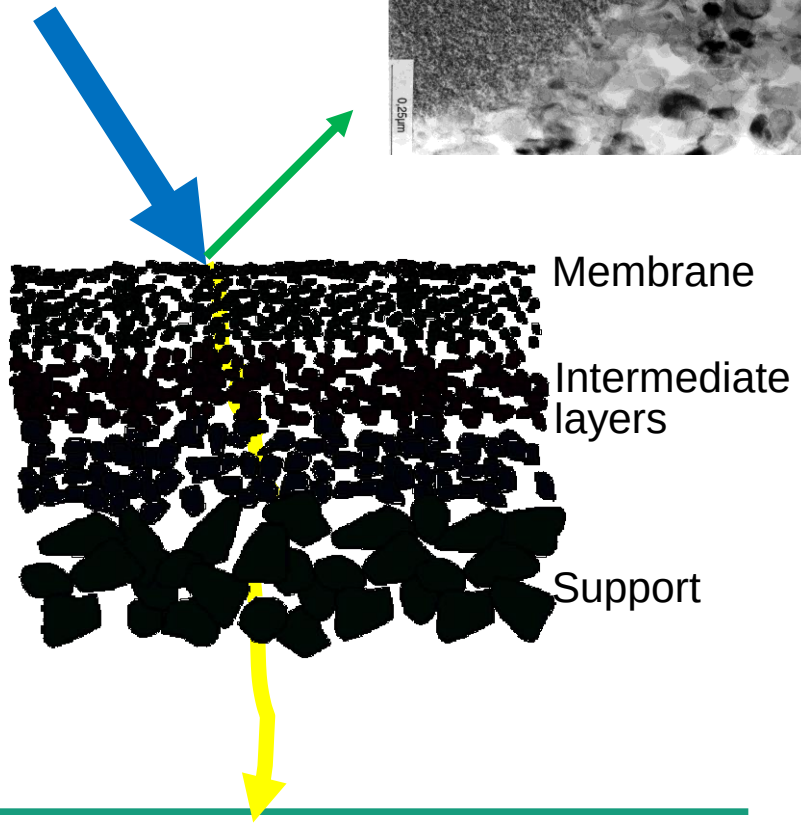
Dense Membranes

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Requirements for high performance membranes

- Membrane thickness as thick as necessary to avoid defects and to get mechanical strength
- Membrane thickness as thin as possible to get high flux ($m^3/(m^2 \cdot h)$ or $(m^3/(m^2 \cdot h \cdot bar)$
- Small pore size (micropores < 2 nm) to separate on a molecular level
- Narrow pore size distribution to get high retention as well as selectivity

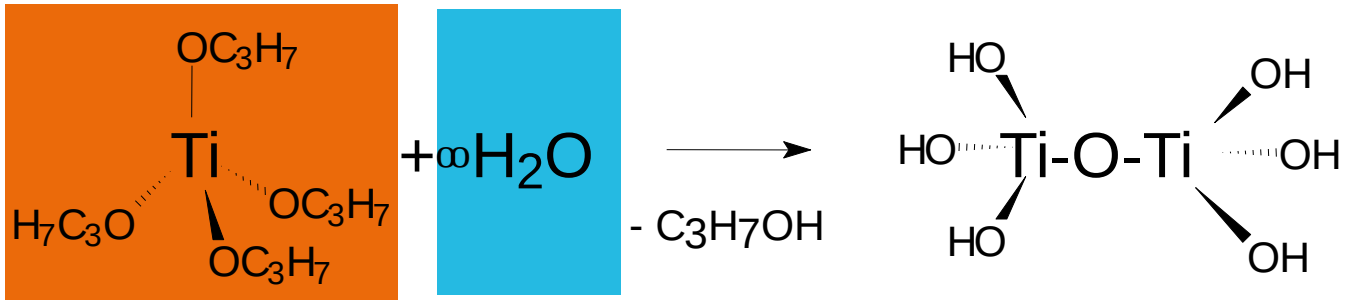


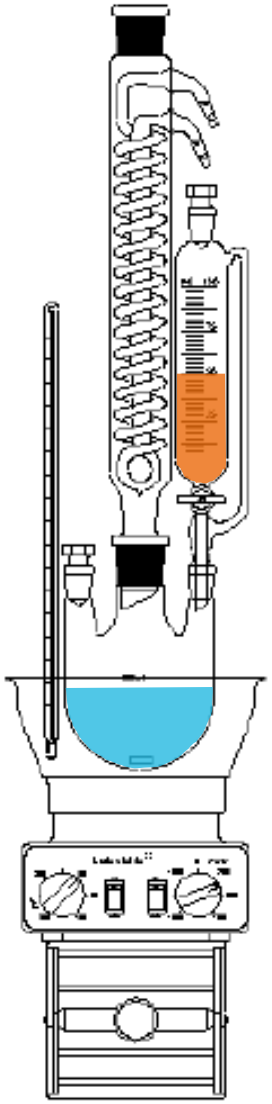


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Intermediate layer by colloidal sol-gel technique



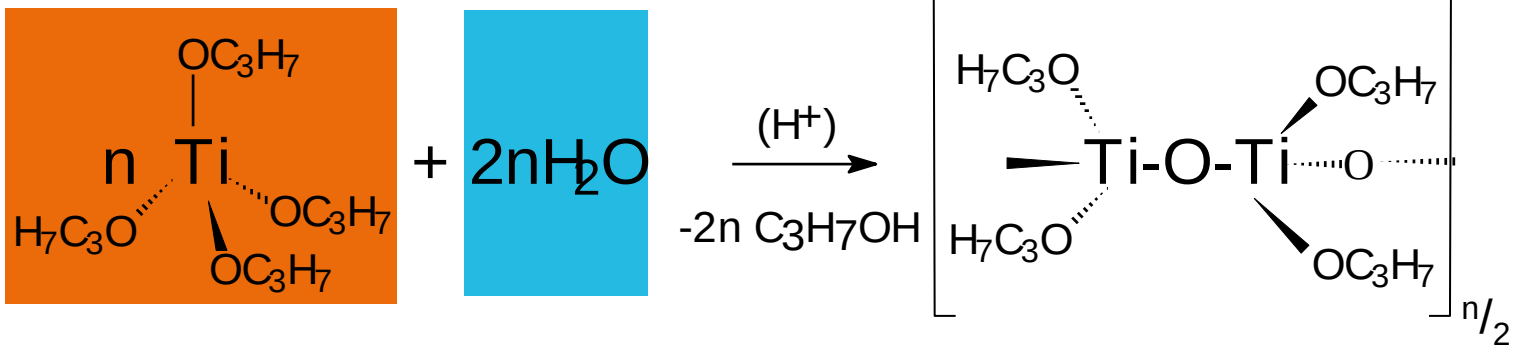


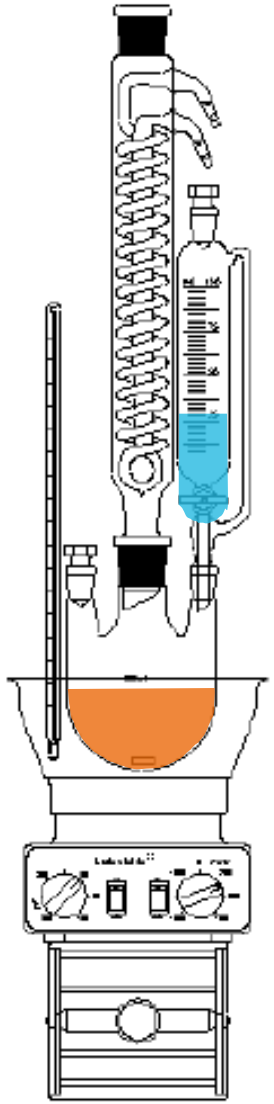
- Colloidal oxide particles
- Particle size: 5-10nm
- Nanocrystalline after sintering
- Pores between particles (crystals)
- Pore size: 3-5nm

© Fraunhofer IKTS

Amorphous oxide membranes

Polymer sol-gel technique





- Mixture of $Ti(i\text{-}OPr)_4$ and $Zr(n\text{-}OPr)_4$
- Longchain polymers
- Structural pores („free volume“)
- Pore size: < 1nm
- Important: clean room conditions and humidity control

S. Zeidler, P. Puhlfürß, U. Kätzel, I. Voigt, J. Membr. Sci. 470 (2014) 421-430

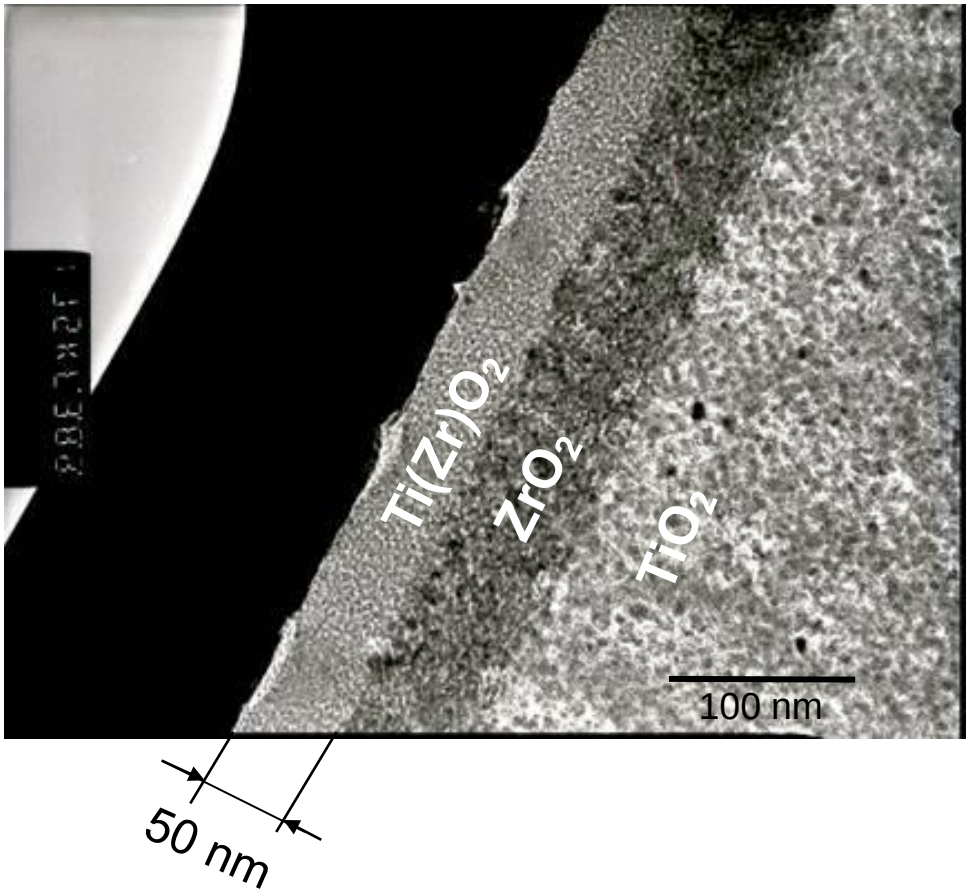
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Amorphous oxide membranes

Nanofiltration membranes

- Material: amorphous $TiO_2(ZrO_2)$
- Molecular weight cut-off MWCO:
  a) 450 g/mol or b) 200 g/mol
- Water flux: a) 20 l/(m^2·h·bar)
  b) 9 l/(m^2·h·bar)
- Membrane thickness: 50 nm
- Pore size: a) 0.9 nm, b) 0.8nm
- Open porosity: 30 %
- Temperature stability: 350 °C
- Pressure stability: ≥ 60 bar
- High chemical stability
  (2 mol/l HCl, 4 mol/l NaOH)



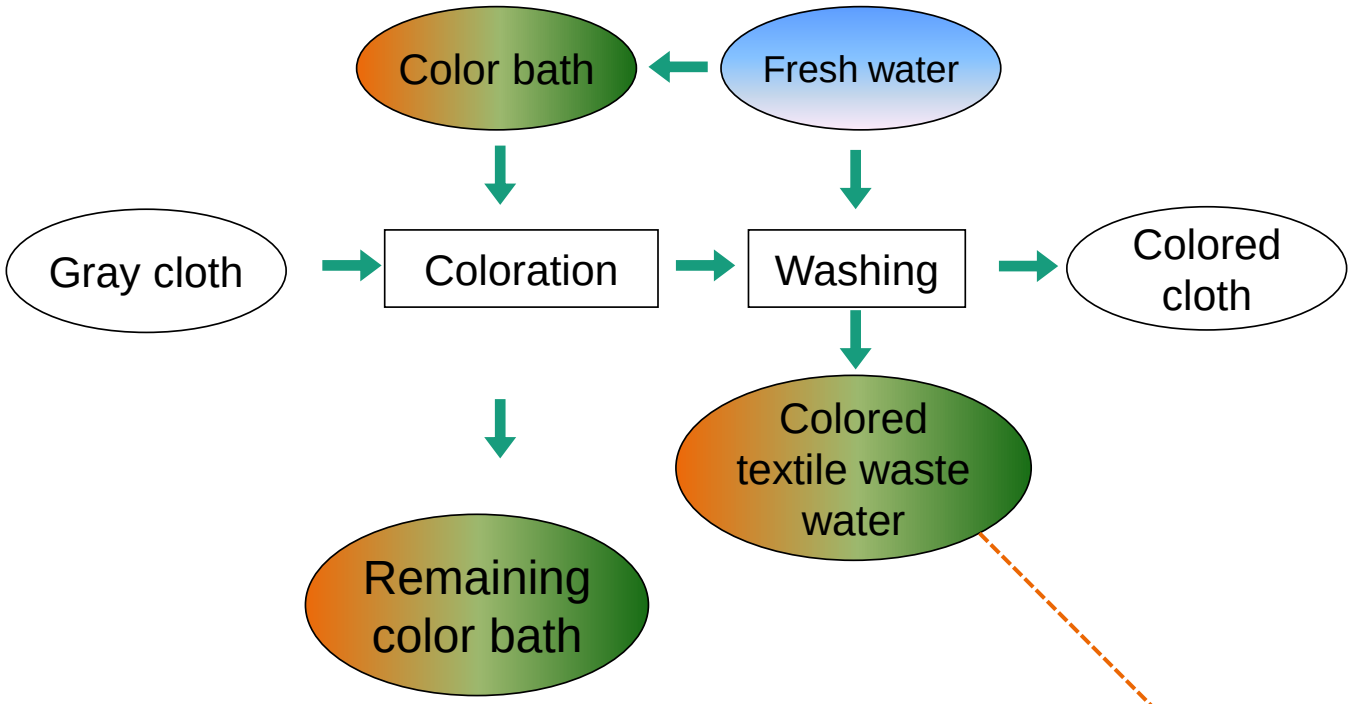
I. Voigt et al., 12th ICIM, 09-13 July 2012, Enschede, The Netherlands

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Amorphous oxide membranes

Waste water from textile industry



COD: 60…6600 mg/l

pH: 3…12

Temp.: 20…90°C

Hydrogen peroxyde!

RIEDEL TEXTIL

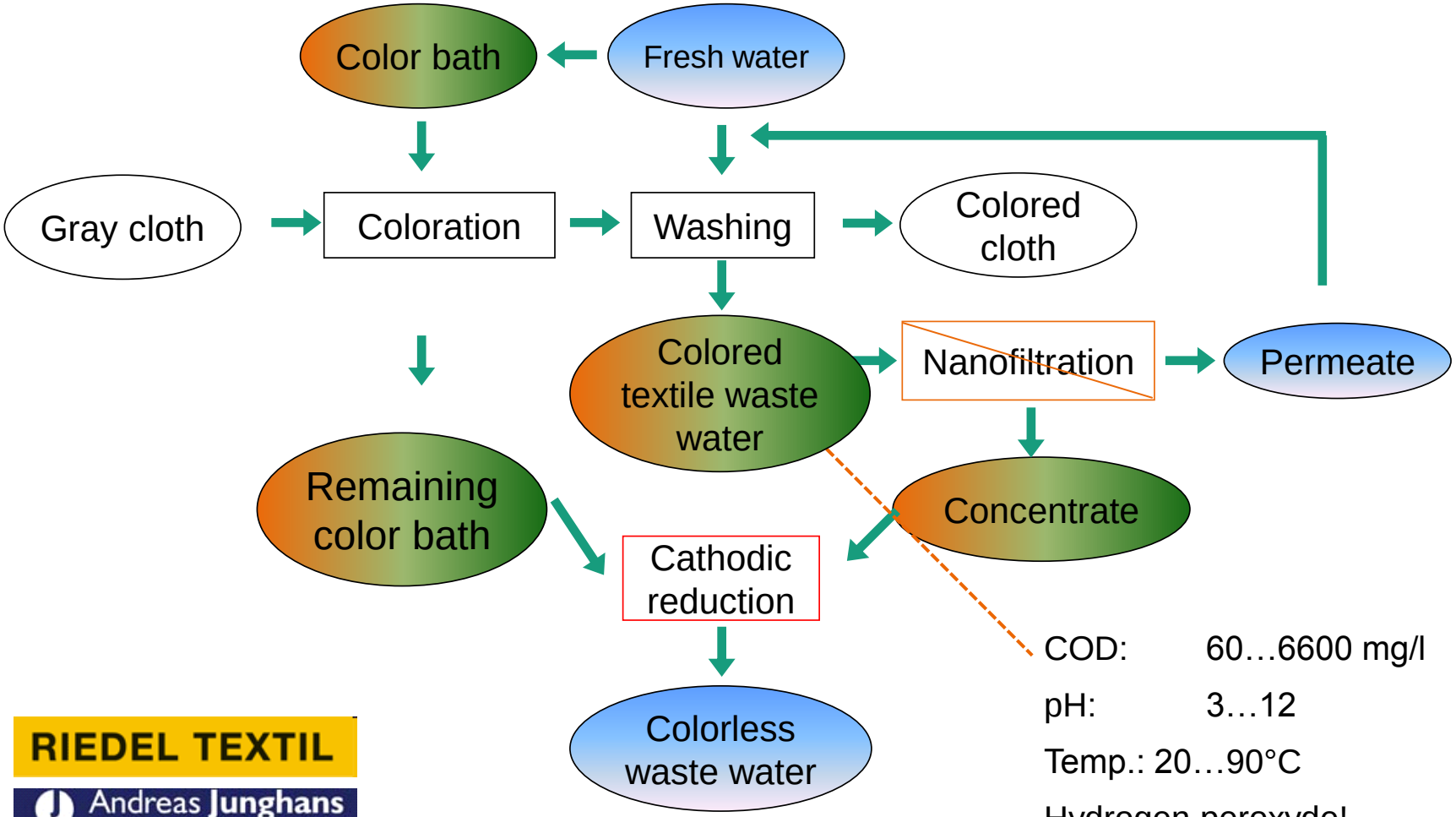
Andreas Junghans
Anlagenbau und Edelstahlbearbeitung

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Amorphous oxide membranes

Waste water from textile industry



RIEDEL TEXTIL

Andreas Junghans
Anlagenbau und Edelstahlbearbeitung

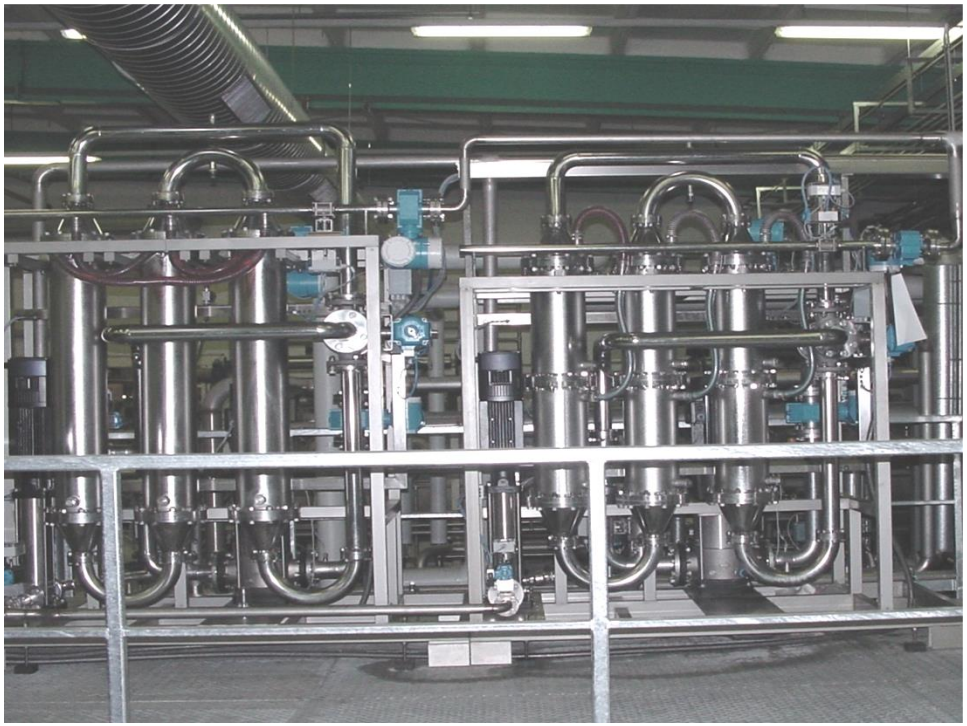
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Amorphous oxide membranes

Waste water from textile industry

RIEDEL TEXTIL

Andreas Junghans
Anlagenbau und Edelstahlbearbeitung



- Commission: May 2002
- Operation mode: feed & bleed
- Concentration factor: 10...20
- Membrane area: 25 m^2
- TMP: 15 bar
- Cross flow velocity: 5 m/s
- Permeate flux: 5 m^3/h (200 $l/(m^2 \cdot h)$)

Membrane replacement 2012
Operating life: 10 years!

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Amorphous oxide membranes
Treatment of “produced water”

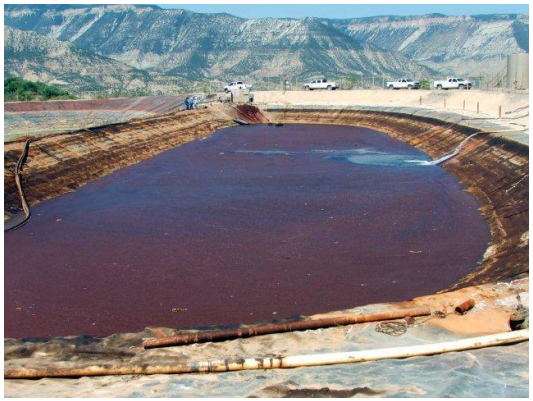
“Produced water”: byproduct in oil and gas industry
(water flooding of oil reservoirs to increase yield, oil sand refinery, fracking)

Challenges: ingredients of „produced water“

- Particles (abrasion)
- Oil and tar (high fouling)
- Salts (high scaling)

⇨ Ceramic membranes

- Separation of oil droplets by microfiltration
- Partial desalination by nanofiltration
- Both together with one step nanofiltration

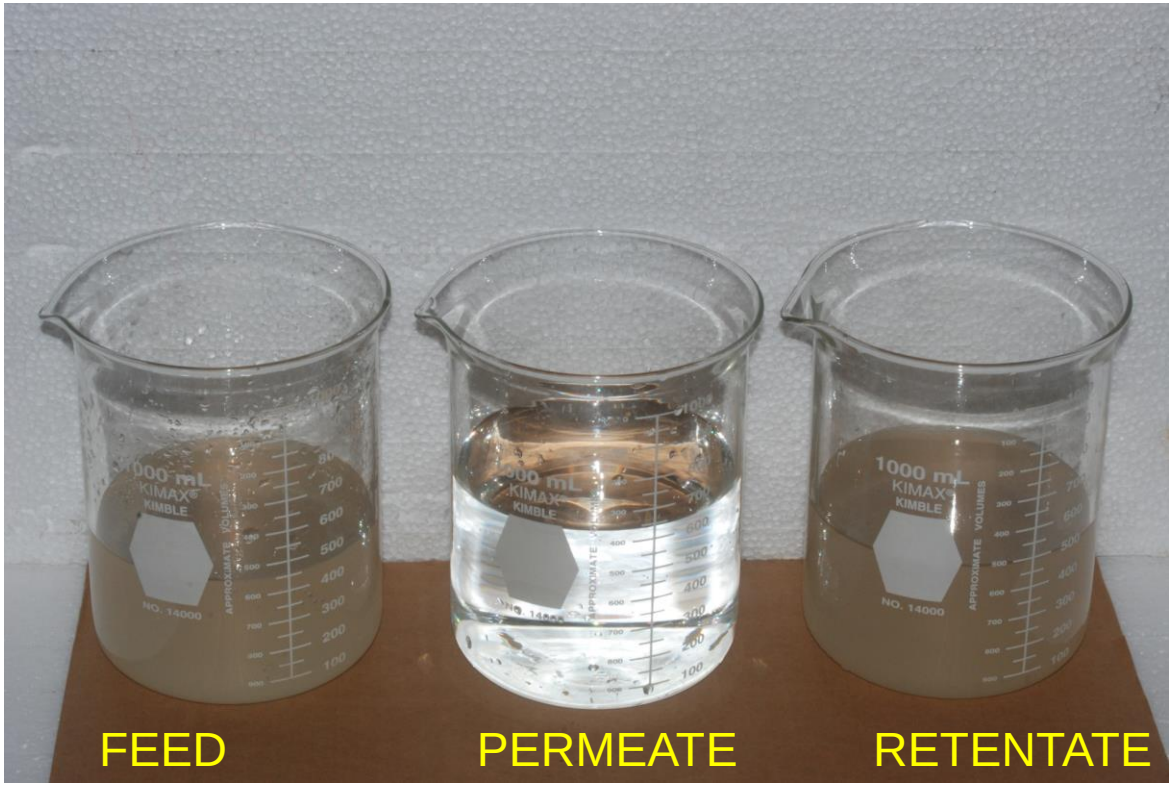


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Amorphous oxide membranes

Treatment of “produced water”

Water treatment from oil sand refinery (Shell, Canada)



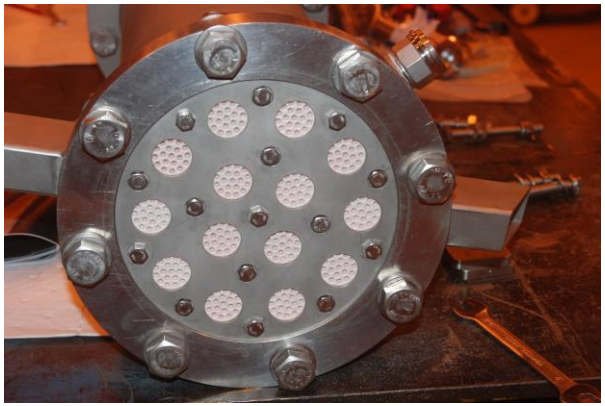
A. Nijmeijer, 13th ICIM, 6-9 July 2014, Brisbane, Australia

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Amorphous oxide membranes
Treatment of “produced water”

- Long term tests in Canada (3.5 m^2 NF-membrane)
- Full particle removal
- Up to 80% di-valent ion removal
- Up to 55% mono-valent ion removal
- Nearly full organics removal
- Flux: 15 l/(m^2h) at 10 bar
- Easy cleaning (1% citric acid for scaling; 1% NaOH for oily layer)
- No damage to filtration layer



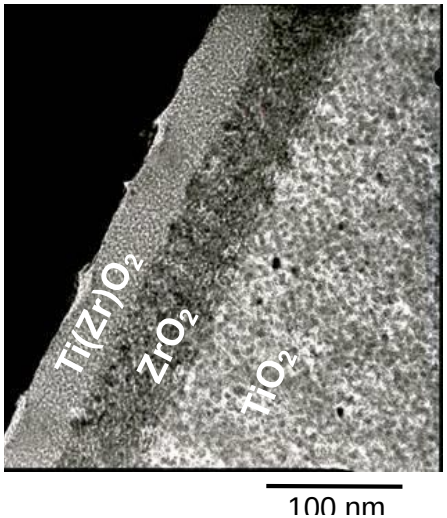


A. Nijmeijer, 13th ICIM, 6-9 July 2014, Brisbane, Australia

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The American Ceramic Society`s 2015 Corporation Environmental Achievement Award

Ceramic nanofiltration membranes for efficient water treatment







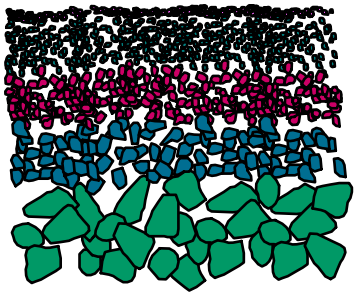
Winners of the last years: Murata Electronics, Toyota Central Research, OSRAM SYLVANIA Products, Pilkington Technology Management Limited, SCHOTT North America

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Environmental and Process Engineering

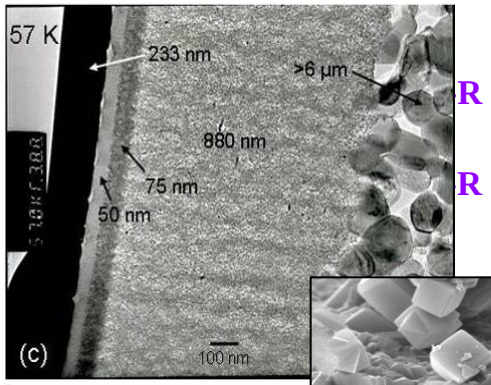
Ceramic Membrane Materials

Structure of ceramic membranes



Ceramic Membranes

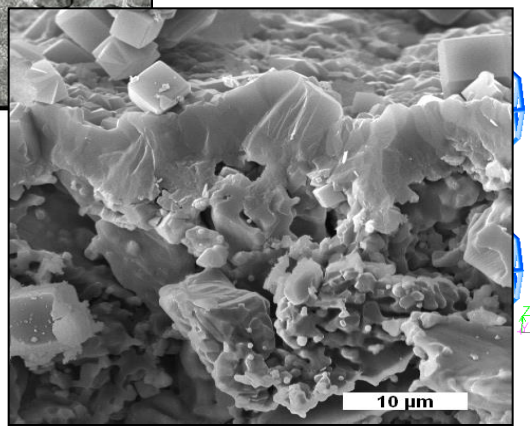
Amorphous



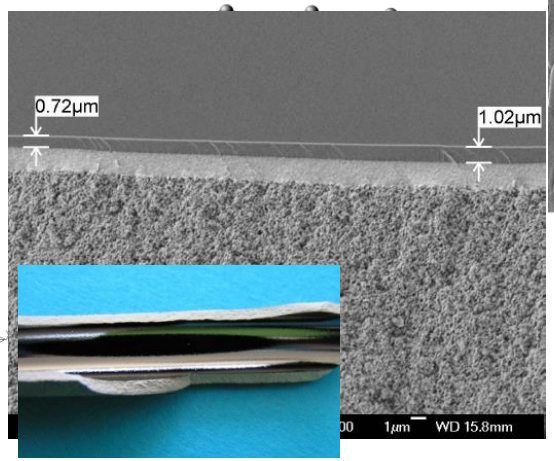
R

R

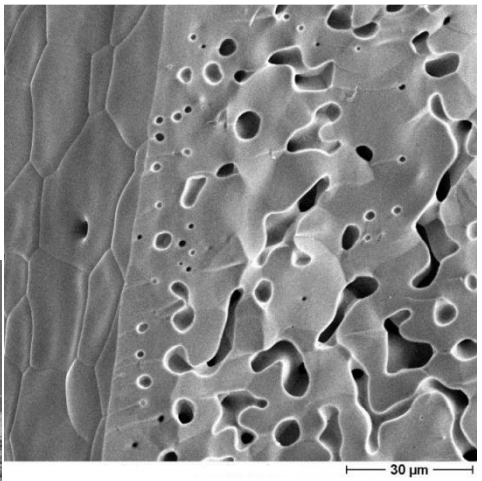
Zeolites



Carbon



MIECs



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Environmental and Process Engineering

Examples of Application



Ceramic Membranes

Amorphous



Wast water cleaning

Zeolites



Bioethanol dewatering

Carbon



MIECs



Oxygen separation

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Environmental and Process Engineering

Examples of Application



Ceramic Membranes

Amorphous

MIECs

Zeolites

Carbon



Wast water cleaning

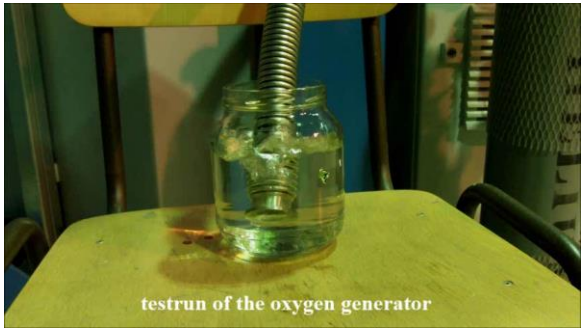


Bioethanol dewatering





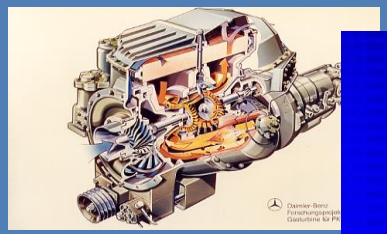
Oxygen separation



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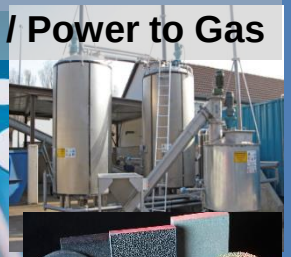
Ceramics for combustion engines and turbines

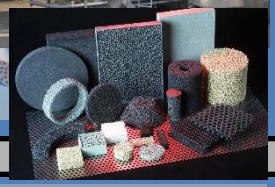




Membranes for Filtration Oxyfuel / Power to Gas







Fuel Cells



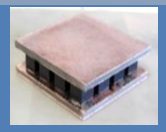


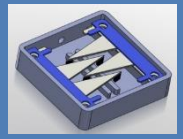


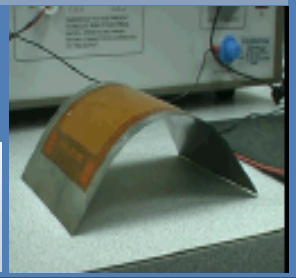
Photovoltaics



Energy Harvesting (Piezoceramics, TEG)



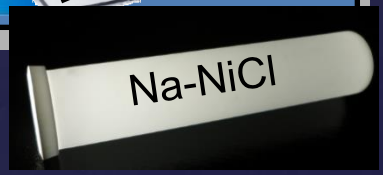




Storage Technology



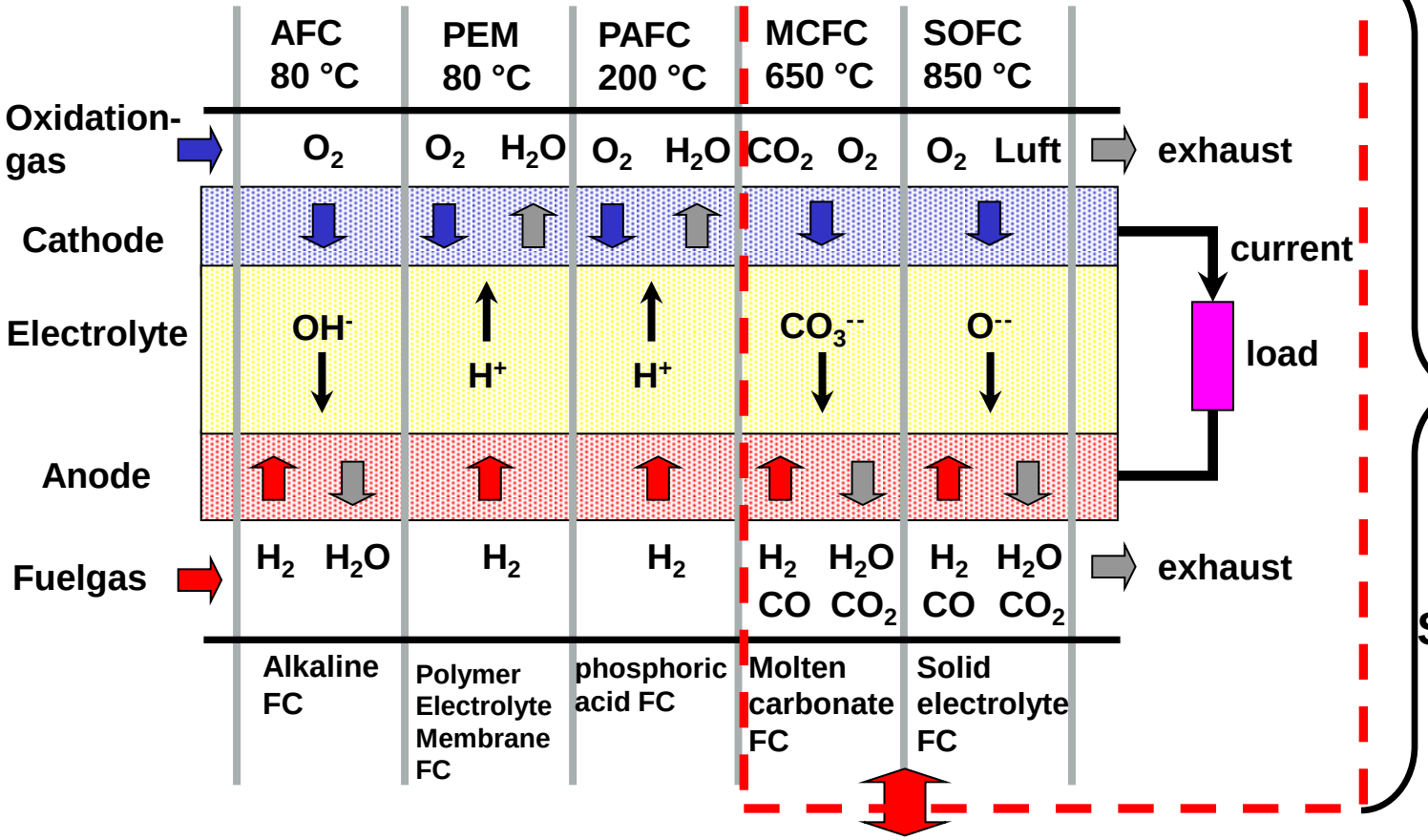
- Li-Battery
- Supercup
- Na-NiCl
- SOEC - (Electrolysis)



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Fuel Cell Types

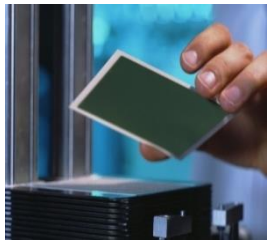
MCFC: > 250 kW





MCFC + SOFC optimum systems for CCHP

SOFC: < 250 kW



Multiple Fuel capable.

Simple Reforming = conventional

Hydrocarbon fuels can be used → no Pt !

© Fraunhofer

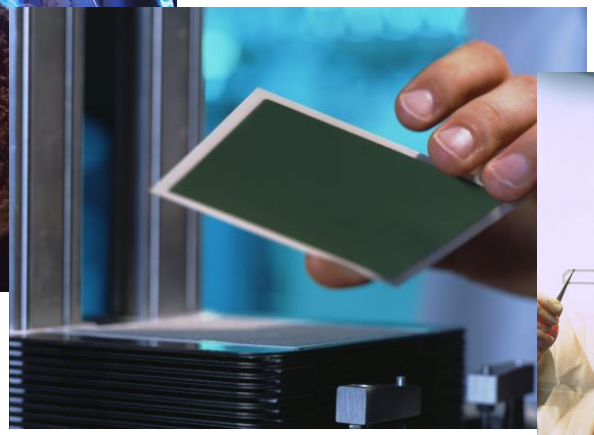
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Smart Ceramcs for Solid Oxide Fuel Cells (SOFC) at IKTS

Material



MEA



Stack

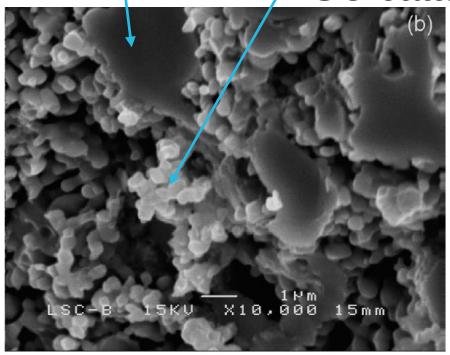


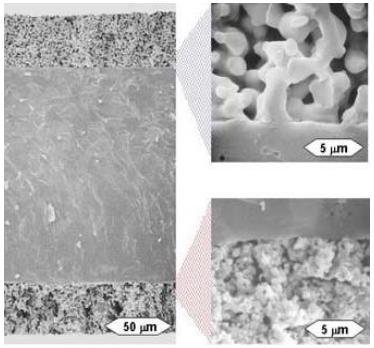
System



3YSZ matrix

LSC catalyst





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IKTS Fuel Cell System Competence

1 W	10 W	100 W	1 kW	10 kW	1 MW
portable	portable	portable	stationary	stationary	








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eneramic by Fraunhofer

Vaillant

staxera:

Mayur RENERGY

sunfire

FuelCell Energy Solutions
Ultra-Clean, Efficient, Reliable Power

hydrogen Ethanol PEFC	Propane Tubular SOFC	LPG Ethanol SOFC	NG SOFC	Biogas + NG SOFC Elektrolyse	Biogas + NG MCFC

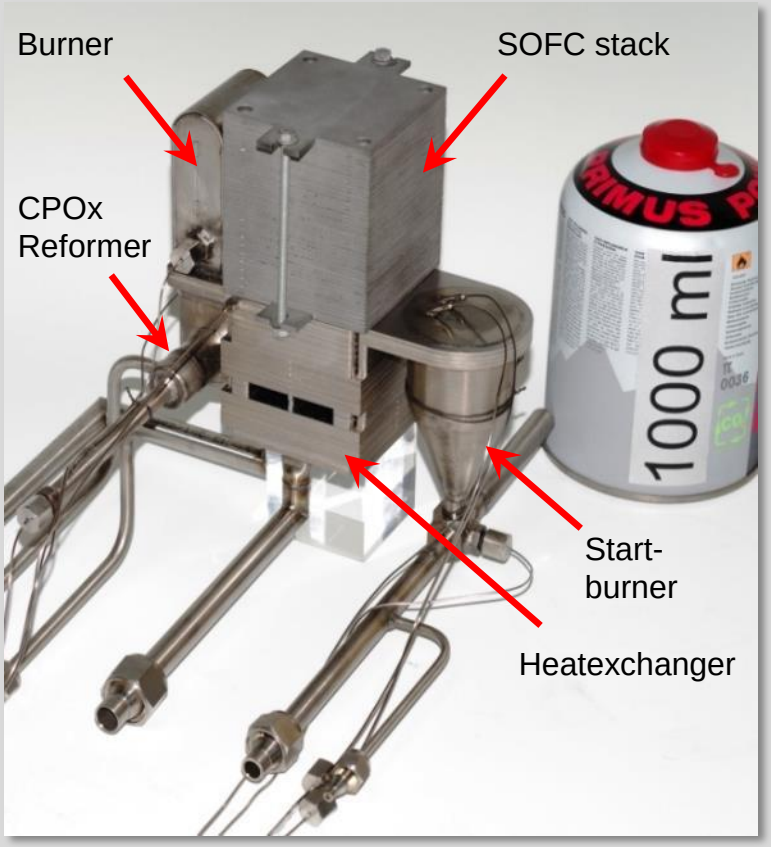
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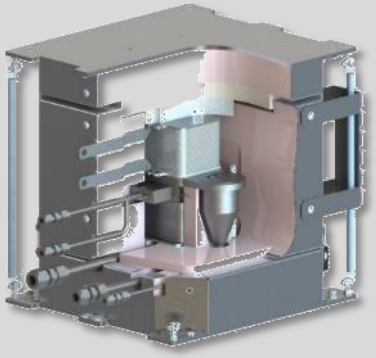
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100 W_{el}, LPG-fueled Portable Power Generator

Core Module



HotBox



Systemintegration



Demonstration / Fieldtest



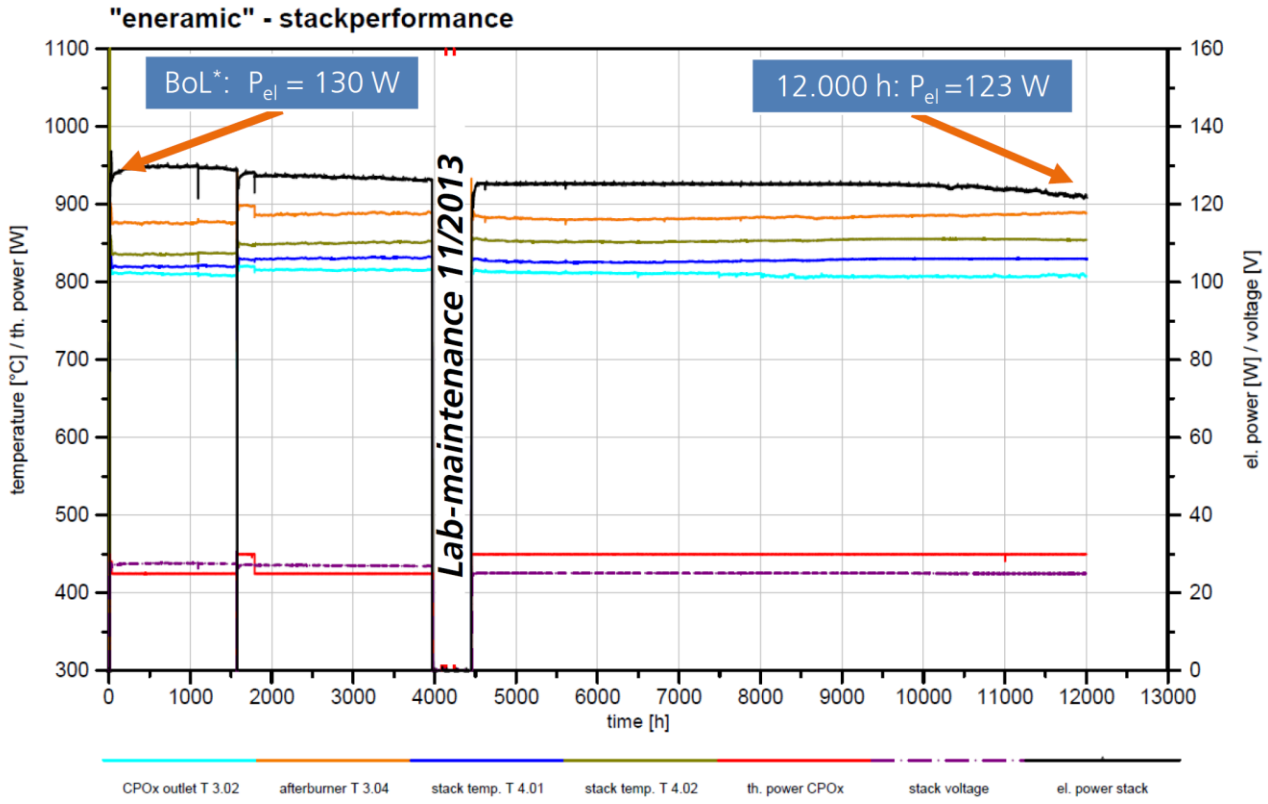




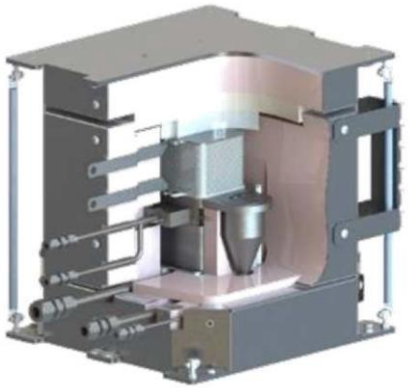
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Lifetime Test (ongoing)

Hotbox Testing incl. Reformer / HEX





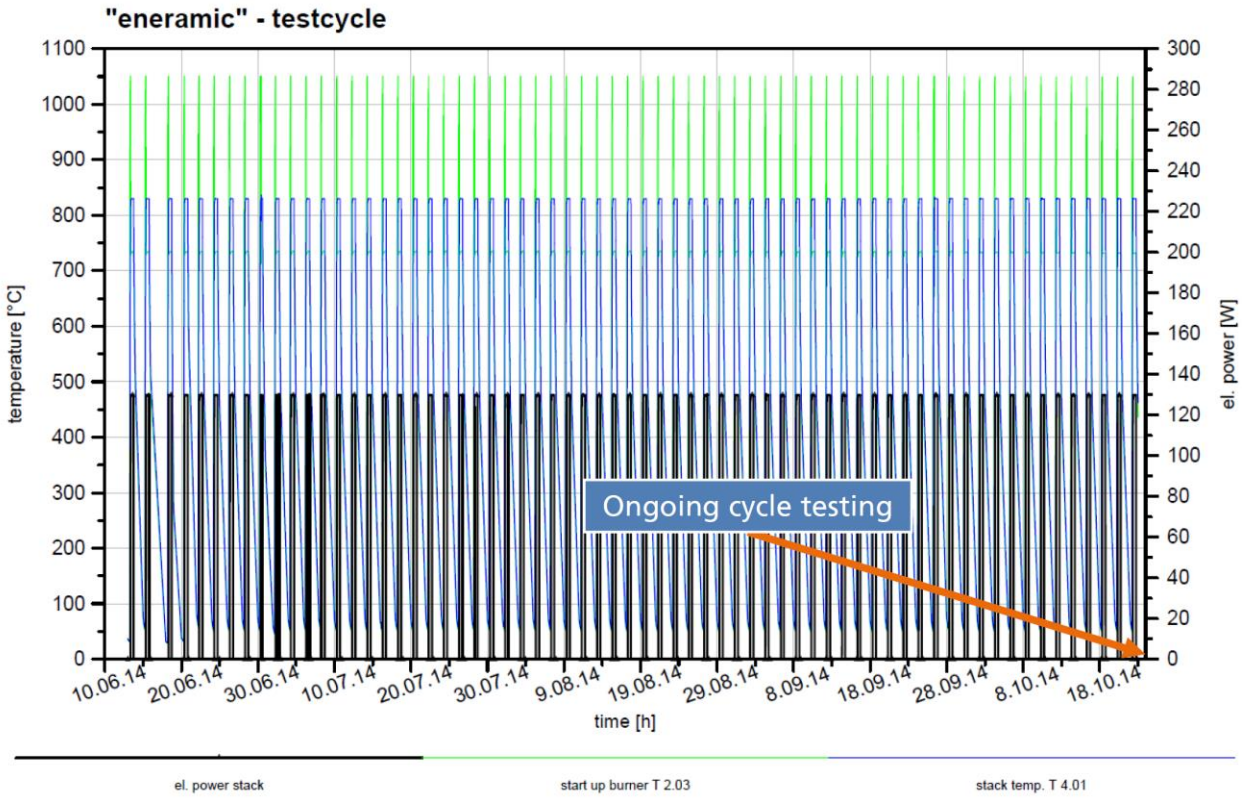


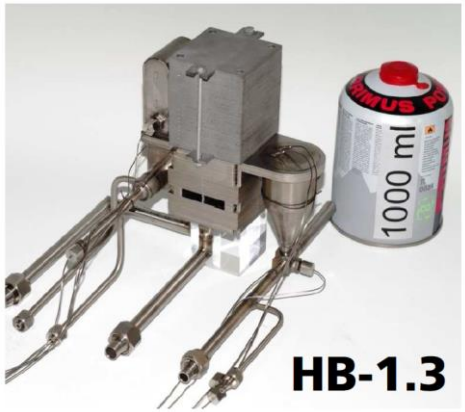
Total power degradation : <0,5 % / 1.000 h

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Cycleability

Hotbox Containing all Hot Components

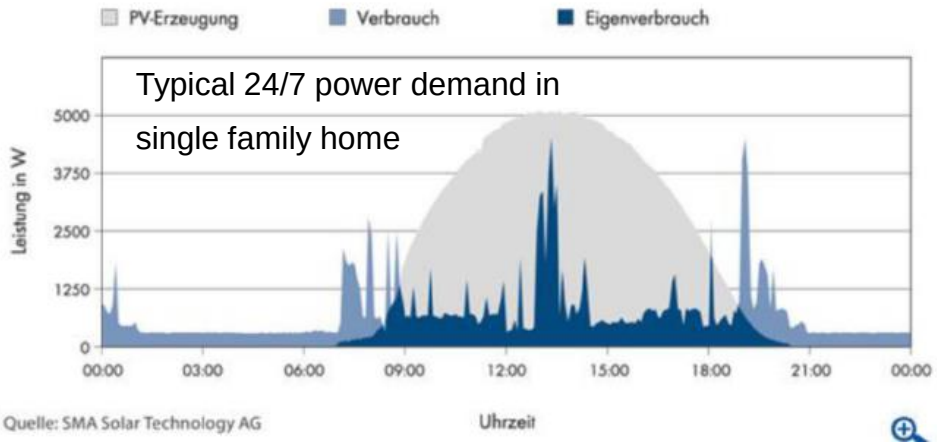


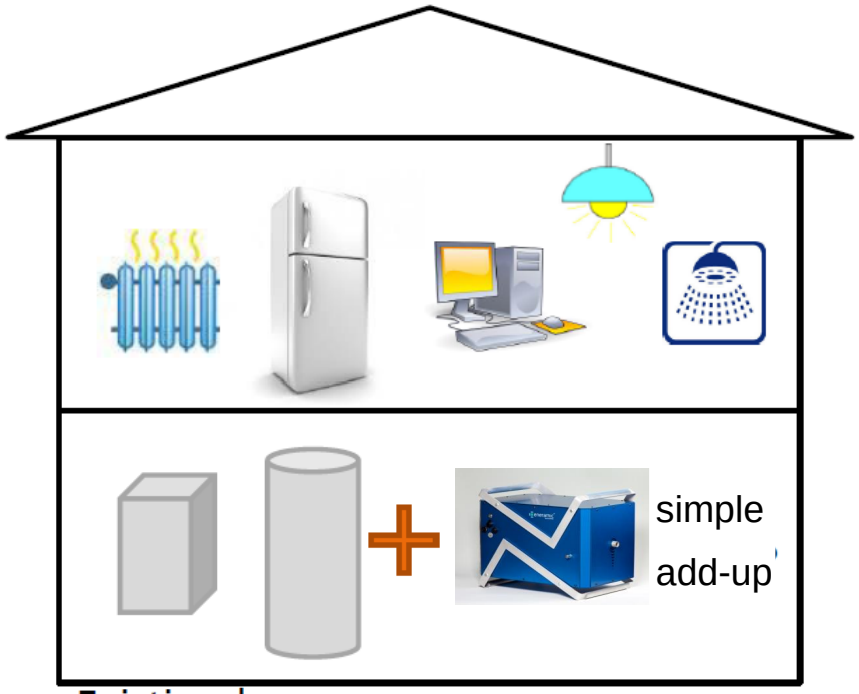


System cycle: Heating rate 8 K/min; 10h @ full load; cooling until 50°C

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Mikro-CHP for base load power supply in single family homes





- Simple add-up CHP system
- 250 W electrical baseload
- 500 W thermal power
- Virt. 100% electrical efficiency
- All-year operation, heat for hot water in summer
- Saves 50% of the electricity bill resp. 2,200 kWh / year
- Enhances lifetime of the existing peakload burner
- Saves 800 kg CO2 / year (equal to 6,500 km in a car)

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MCFC: Market proven!



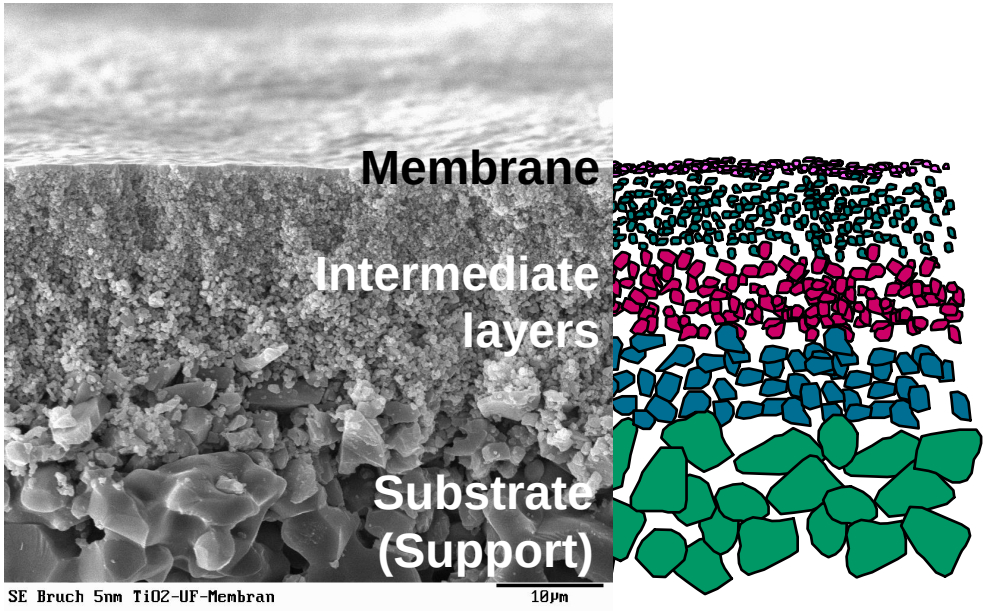
More than 80 Direct FuelCell® plants are running in the field

300MW Fuel Cell power in operatoion

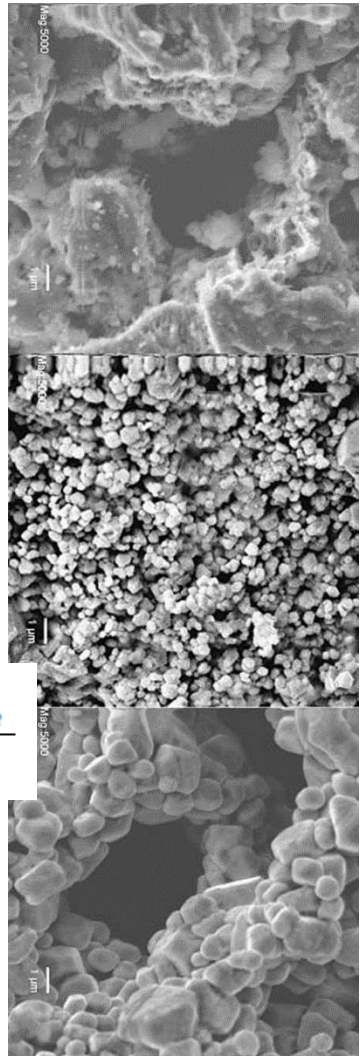
→ Maritime applications

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Structure of ceramic membranes



Morphology of Carbonate Fuel Cell



Anode, a

Electrolyte, e

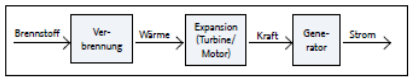
Cathode, c

$$\frac{\gamma_c \cos\vartheta_c}{D_c} = \frac{\gamma_a \cos\vartheta_a}{D_a} = \frac{\gamma_e \cos\vartheta_e}{D_e}$$

Design of the cell active components ensures that:

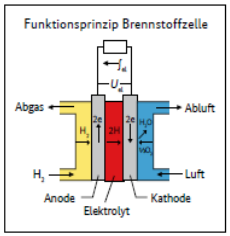
- **Matrix pores are filled with electrolyte (via capillary force) during entire operation**
- **Large pores in anode and cathode (gas-diffusion electrodes) remain unfilled with electrolyte**

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Brennstoffzellen setzen in der Regel Wasserstoff um. Beim Einsatz von Erdgas sind Anlagen erforderlich, die daraus Wasserstoff erzeugen. Weiterhin werden Hilfsaggregate, wie Pumpen und Lüfter, für die Zufuhr der Betriebsmittel und zur Kühlung sowie gegebenenfalls Wechselrichter benötigt. In der Leistungsklasse für große Gebäude, Stadtquartiere oder Industriebetriebe von einigen 100 kW wurden bereits mehrere Anlagen kommerziell installiert. Einsatzgebiete sind die effiziente Strom- und Wärmeerzeugung (Kraft-Wärme-Kopplung) und die effiziente Realisierung einer gesicherten Stromversorgung, zum Beispiel für Rechenzentren. Es gibt unterschiedliche Typen von Brennstoffzellen, die sich vor allem im verwendeten Elektrolyt und den daraus resultierenden Betriebsbedingungen unterscheiden.



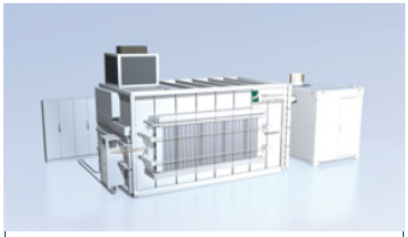


Brennstoffzellentyp	Einsatz- und Leistungsbereich
Alkalische Brennstoffzelle (AFC)	v. a. Raumfahrt 1–20 kW
Polymermembran-Brennstoffzelle (PEMFC, HT-PEM, DMFC)	Antrieb 50–150 kW Hausenergie 1–10 kW Spezielle Märkte wenige Watt bis 50 kW
Phosphorsäure-Brennstoffzelle (PAFC)	Kraft-Wärme-Kopplungs-Anlage 100–1.000 kW
Schmelzkarbonat-Brennstoffzelle (MCFC)	Kraft-Wärme-Kopplungs-Anlage 100–1.000 kW
Festoxid-Brennstoffzelle (SOFC)	Hausenergie 1–10 kW Bordstrom 1–20 kW Kraft-Wärme-Kopplungs-Anlage 20–1.000 kW Kraftwerk >1 MW

Die Schmelzkarbonat-Brennstoffzelle im BMBF

Vorteil der eingesetzten Schmelzkarbonat-Brennstoffzelle (Molten Carbonate Fuel Cell, MCFC) ist die hohe Betriebstemperatur von 650 °C, die eine effiziente Abwärmenutzung bei ca. 400 °C und den Einsatz kostengünstiger Katalysatormaterialien ermöglicht.

Die Zelle kann direkt mit Erdgas betrieben werden, da die Abspaltung des Wasserstoffs (Reformierung) zellintern erfolgt. Andererseits stellt der Elektrolyt hohe Materialanforderungen, und es ist ein zusätzlicher Kreislauf für die Rückführung des Kohlendioxids notwendig, weil dieses für die Reaktion benötigt wird.



Charakteristika der Brennstoffzellenanlage:

Typ: Schmelzkarbonat-Brennstoffzelle (Molten Carbonate Fuel Cell, MCFC)
Elektrolyt: karbonatbasiert
Betriebstemperatur: 600–650 °C
Brenngas: Erdgas
Leistung: 250 kW elektrisch, 160 kW thermisch (Nutzwärme 88/83 °C)
Wirkungsgrad: 47 % elektrisch, 79 % gesamt (bezogen auf den unteren Heizwert)
Einsparung ggü. getrennter Erzeugung (Strommix + Gaskessel): ca. 30 %

Sowohl die Zelltechnologie als auch das effiziente Medien- und vor allem Wärmemanagement sind Gegenstand intensiver, von der Bundesregierung geförderter Forschungs- und Entwicklungsarbeiten.

Forschungs- und Technologieförderung

Über das Nationale Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie (NIP) werden Forschung und Entwicklung sowie Demonstration in den Bereichen Verkehr, stationäre Energieversorgung, spezielle Märkte und Wasserstoffbereitstellung in einem Umfang von rund 700 Millionen Euro (2006–2016) gefördert. Das Programmbudget mit den Eigenanteilen der Industriepartner ist doppelt so hoch.

Das BMBF fördert zusätzlich Grundlagenforschung zur Verbesserung der Strukturen und Anwendungen von Brennstoffzellenkomponenten. Ziel ist vor allem die Substitution teurer Materialien.

Die hier eingesetzte MCFC-Technologie wurde mit Förderung des BMWi bei der Motoren- und Turbinen-Union Friedrichshafen GmbH entwickelt, deren Aktivitäten 2012 von der deutschen Fuel Cell Energy Solutions GmbH übernommen wurden. Die Installation im Neubau des BMBF ist der erste kommerzielle Auftrag an das junge Unternehmen. Es verbindet die Erfahrungen des US-amerikanischen MCFC-Herstellers Fuel Cell Energy Inc. in einem Joint Venture mit den technologischen Stärken des Fraunhofer-Instituts für Keramische Technologien und Systeme – IKTS in Dresden.

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Das Titelbild des Flyers zeigt das Bundesministerium für Bildung und Forschung in Berlin.

FORSCHUNG

Sie haben 12 entgangene Anru

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Versatile Applications

Carbon-Neutral Renewable Hydrogen

Renewable biogas from wastewater treatment facility



Tri-generation DFC-H2



Hydrogen Fueling Station/Pipeline



Heat

Ultra-clean Electricity

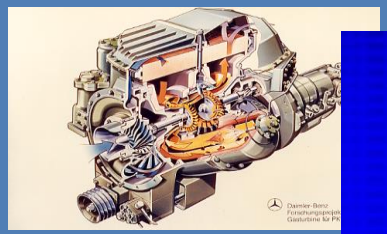
Hydrogen

Example: DFC 1500H: 1.1MWel – 0.44MWth – 635Kg H2/Day
or alternatively 1.3MWel – 0.64MWth – 100Kg H2/Day
- ratio can be adjusted in operation
- H2 in 5*9 Quality

© 2012-14 FuelCell Energy Solutions GmbH



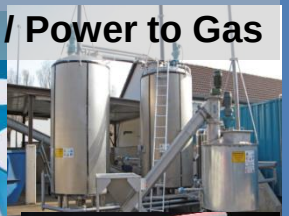
Ceramics for combustion engines and turbines

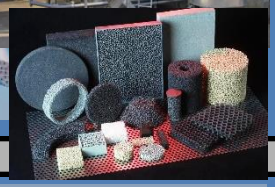




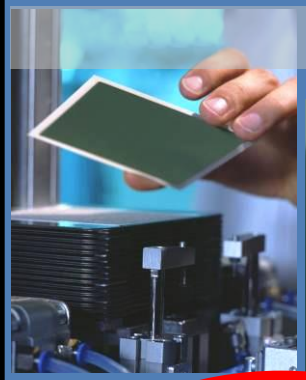
Membranes for Filtration Oxyfuel / Power to Gas







Fuel Cells

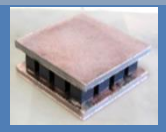


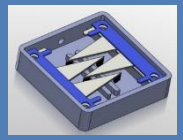


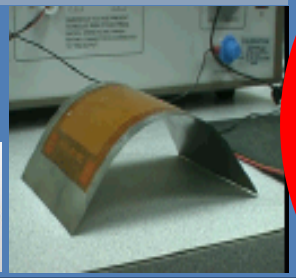
Photovoltaics



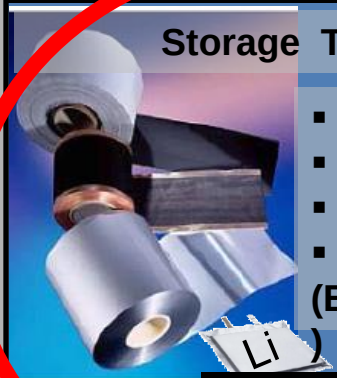
Energy Harvesting (Piezoceramics, TEG)



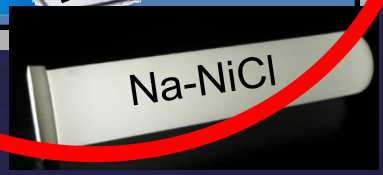




Storage Technology

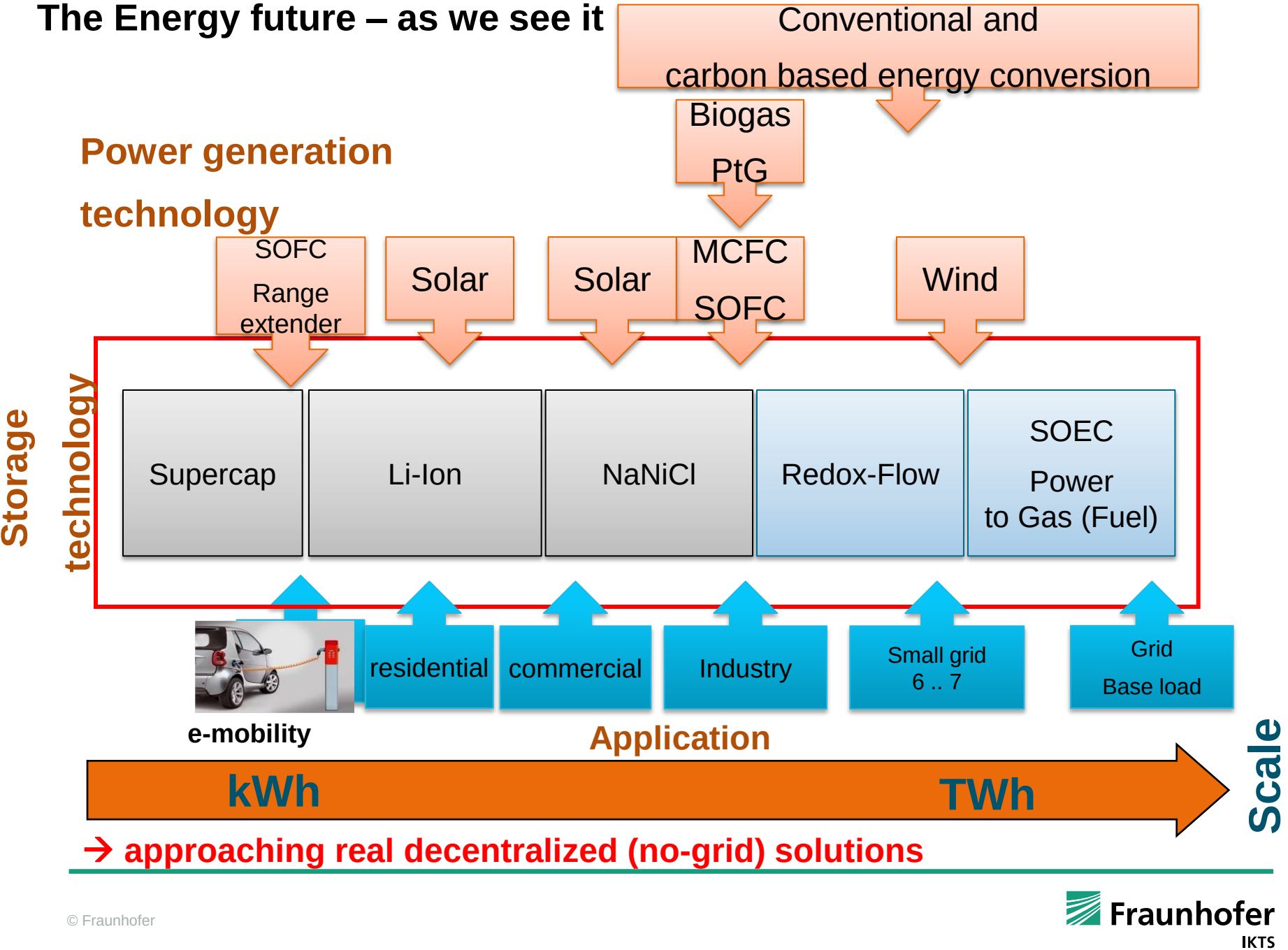


- Li-Battery
- Supercup
- Na-NiCl
- SOEC - (Electrolysis)



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The Energy future – as we see it



© Fraunhofer

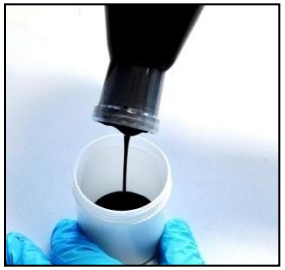
Fraunhofer IKTS

Li-Ion Battery value chain

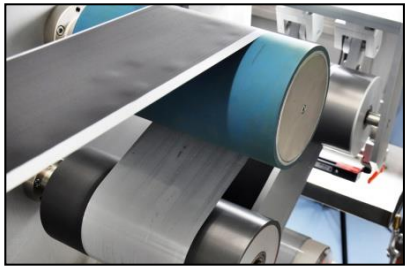
Powder synthesis	Slurry Mixing	Electrode manufacturing	Cell assembly & packaging	Cell testing



- Powder synthesis and modification
- Methods for analysis and optimization of thermal process
- Methods for characterization of powders (FESEM, XRD; Raman; thermal properties; particle size)



- Development of an adapted slip compositions for the coating process
- Sophisticated methods of slurry characterization and optimization



- Efficient methods for slurry mixing
- Development of technologies for coating of electrode films





- Material and electrode characterization
- Sophisticated spectro-electrochemical characterization (impedance, Raman,…)

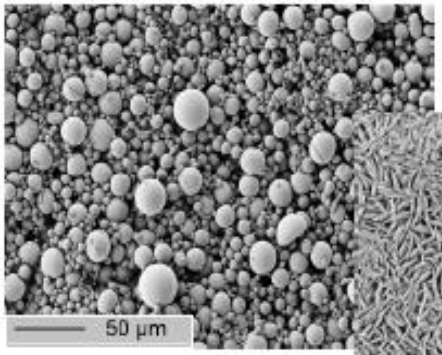


- Electrical and thermal characterization of commercial cells
- Stationary and dynamic modeling of battery cell performance

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Ceramic technology determines performance of batteries

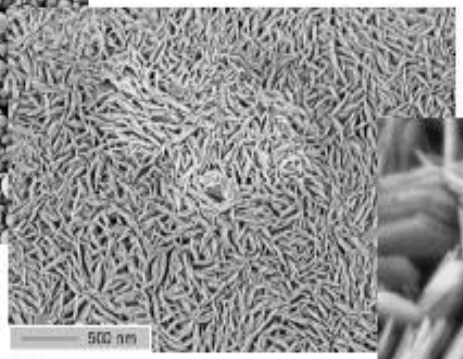


Makro-,

- *Particle Size*
- *Particle Shape*
- *Particle Size Distribution (PSD)*

…

Tap density
Capacity
Processing

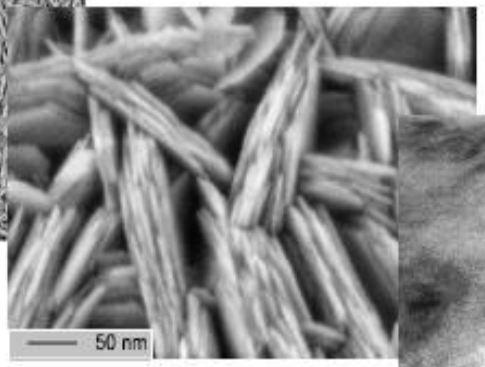


Meso-,

- *Grain Size*
- *Grain Shape*
- *Porosity*

…

Discharge current
Cycle stabilty

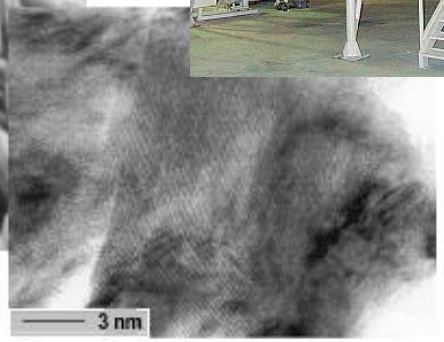


Micro-,

- *Crystal Structure*
- *Crystallite Size*
- *Crystallite Shape*

…

Power density
Life time



Atomic Structure

- *Vacancies, Interstitials*
- *Dislocations*
- *Stacking faults*

…

Safety



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Efficient manufacturing methods for high-performance lithium ion batteries: From Lab. to Fab.

- **Pilot scale production of Li-Ion-Batteries**
- Development of optimized manufacturing methods along the entire value chain of lithium ion cell production



Slurry mixing → Electrode manufacturing → Cell assembly + packaging → Cell testing → Battery assembly

IKTS

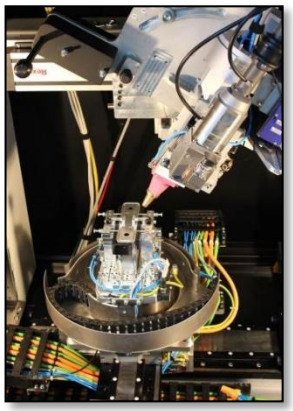




TKSY







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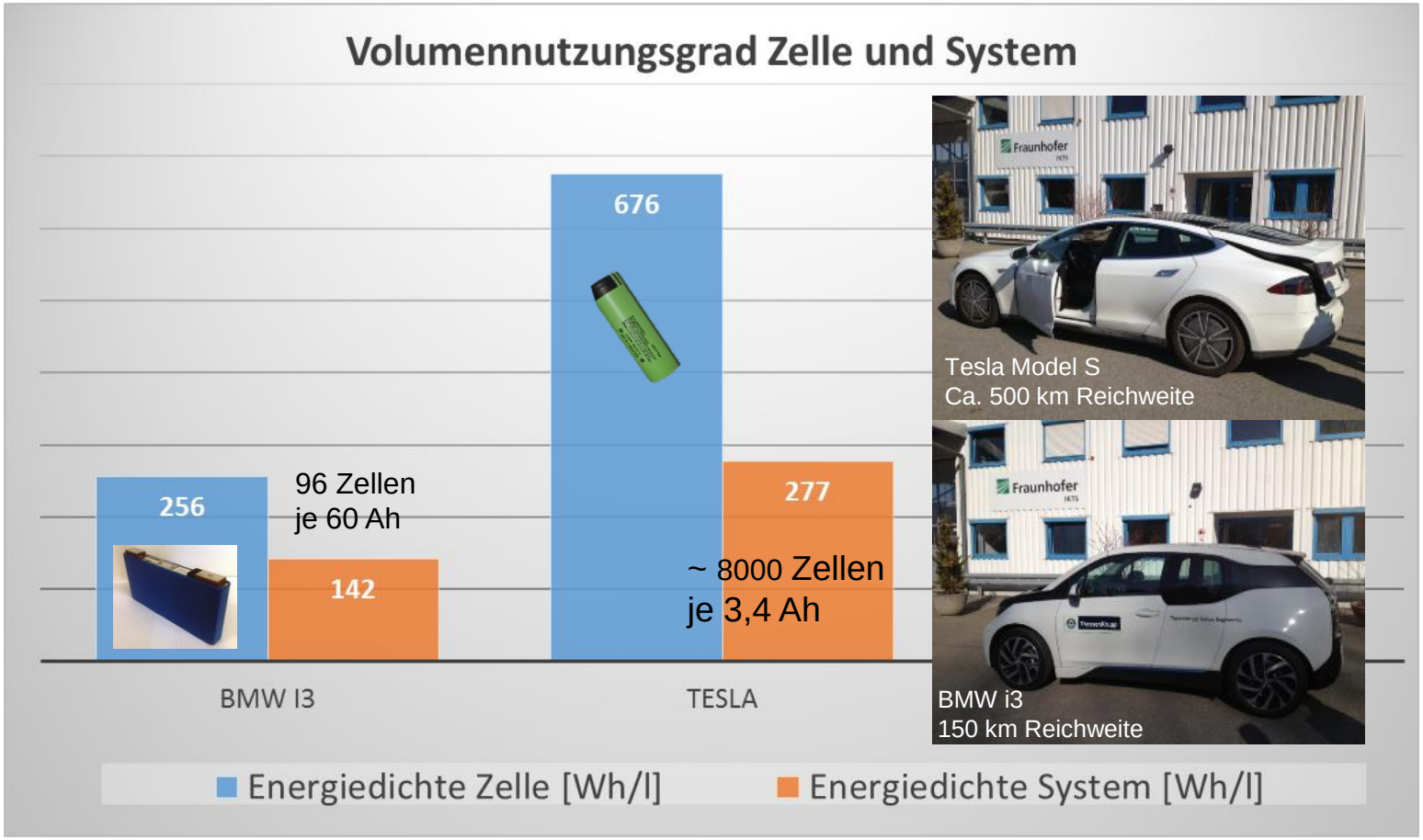
ThyssenKrupp System Engineering

KMS TECHNOLOGYCENTER

AWEBA Werkzeugbau GmbH Aue

Fraunhofer IKTS

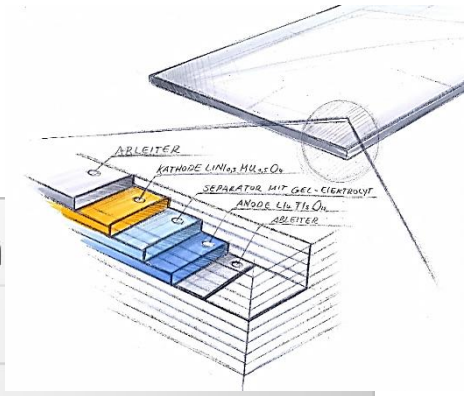
Example: Electromobility

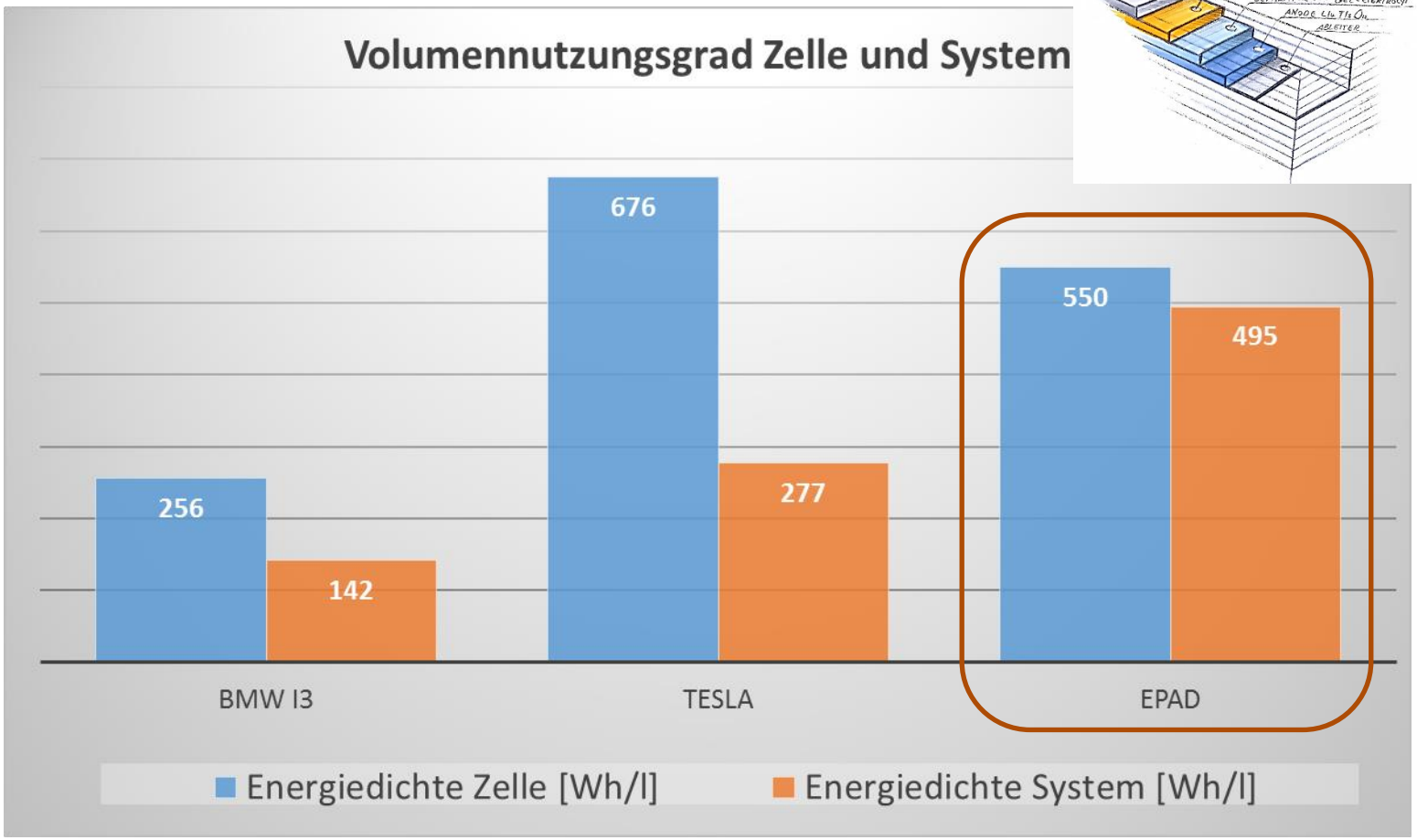


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ThyssenKrupp System Engineering | automotive engineering iav | Fraunhofer IKTS

$LiNi_{0,5}Mn_{1,5}O_4/Li_4Ti_5O_{12}$ – Bipolar battery





VERTRAULICH

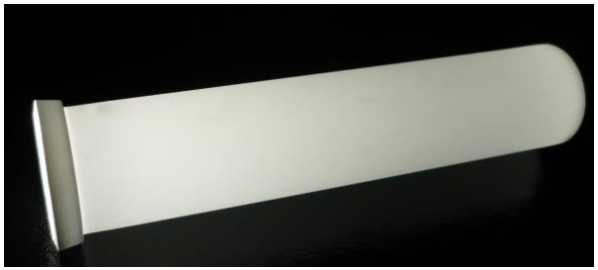
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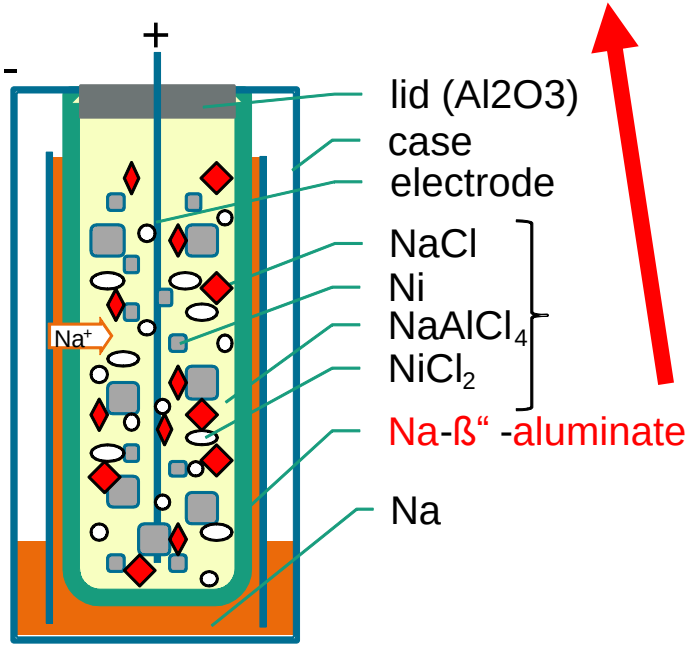
ThyssenKrupp System Engineering | automotive engineering | iav | Fraunhofer IKTS

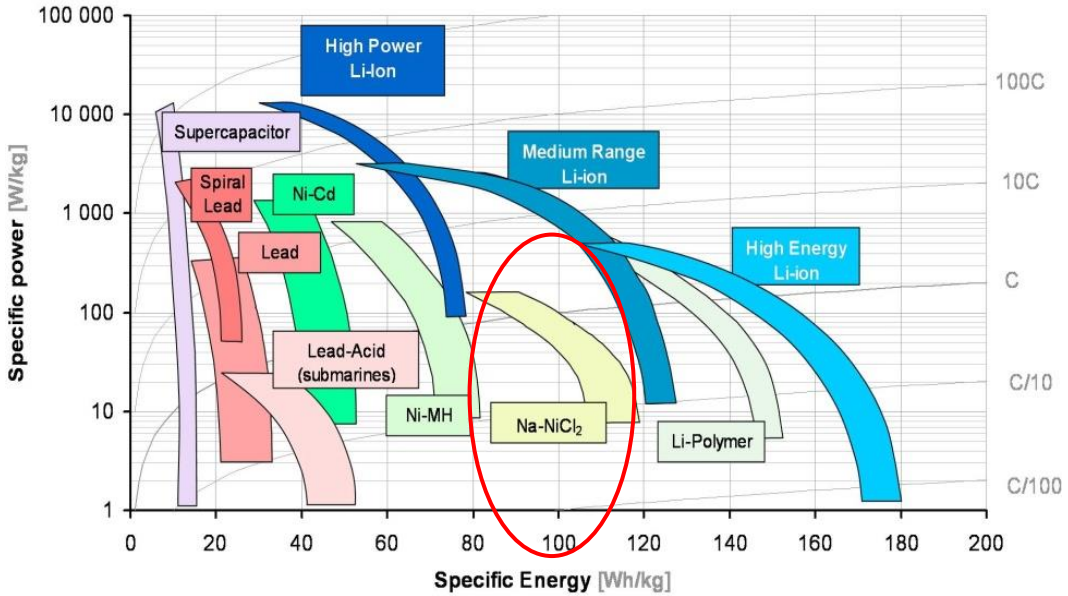
$Na/NiCl_2$ solid state electrolyte batteries for stationary applications

Operation principle (Zebra)

- $NiCl_2 + 2Na \leftrightarrow Ni + 2NaCl$, $E_0 = 2{,}58$ V
- Electrolyte Na-ß“-aluminate **(ceramics)**
- Cathode: Ni, common salt (NaCl), $NiCl_2$, $NaAlCl_4$
- Anode: Na (melt)
- Operation temperature: 270 – 350 °C







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- confidential -

Material costs: NaNiCl (long run marginal costs)

Material	kg/cell	kg/kwh	$/kg	$/cell	$/kWh
Ni (powder + sheet)	0.15	1.53	11.6	1.74	17.75
Iron (powder + sheet)	0.14	1.43	3.36	0.47	4.80
Copper	0.03	0.31	2	0.06	0.61
Halide salts	0.22	2.24	0.77	0.17	1.73
beta-alumina (boehmite)	0.14	1.43	2.38	0.33	3.40
Total	**0.68**	**6.94**	**4.08**	**2.77**	**28.28**

source: Fiamm

Tab. 1 ZEBRA Cell ML3P Material Cost



Ni-prize
2004 - 2014

13 $

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reduction of production cost by factor 10

Dry pressing



Flat substrates
∅ 20 bis 30 mm,
thickness 0,5 to 2 mm

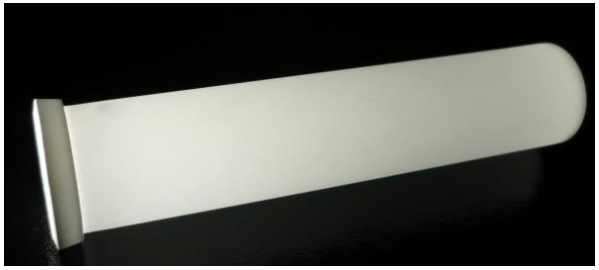
Extrusion

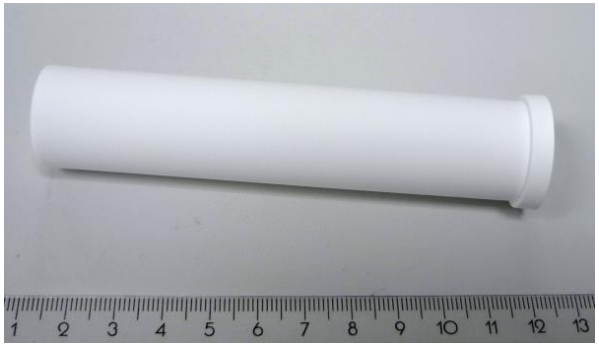




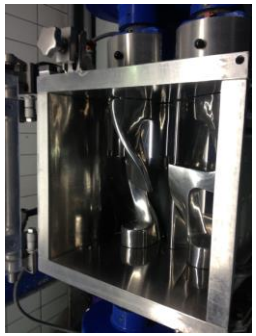
Tubes ∅ 20 bis 60 mm,
wall. 1,5 mm, legth up
to 600 mm

Isostatic pressing





cost-reduction: factor 10





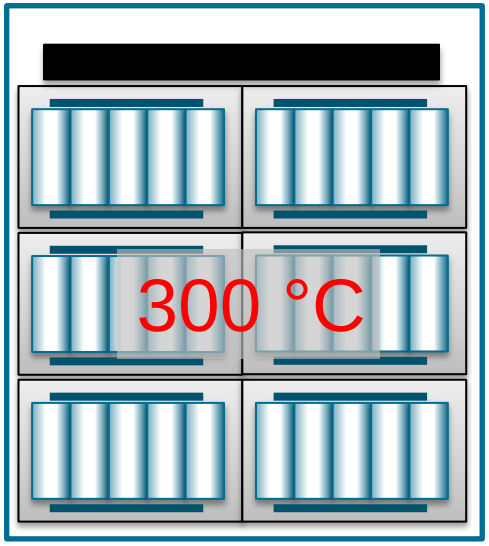


Beakers ∅ 20 mm,
wall thickness. 1,5 mm,
length 150 mm

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Example: stationary battery / Na-Batterie vs. Li-Batterie

Na-Battery



+ 50°C

ΔT = 250°C

ΔT = -10°C

- 30°C

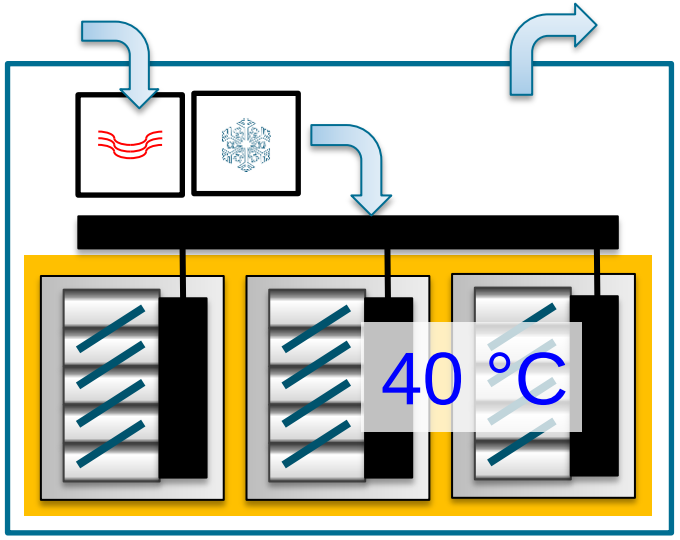
ΔT = 330°C

ΔT = 70°C



- Cell cost : 100 € / kWh
- System : 300 € / kWh
- Inherently safe !
- Marginal electronics / BMS
- Radiation self cooling
- Thermal insulation not dependent on environment

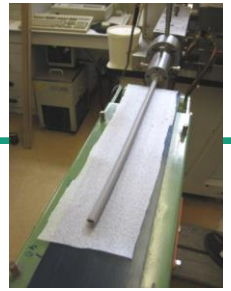
Li-Battery



- cell: 300 € / kWh
- System: 1200 € / kWh
- Not safe (external efforts required)
- BMS and Symmetrisierung
- Active heating/cooling required
- Life time depends on environment



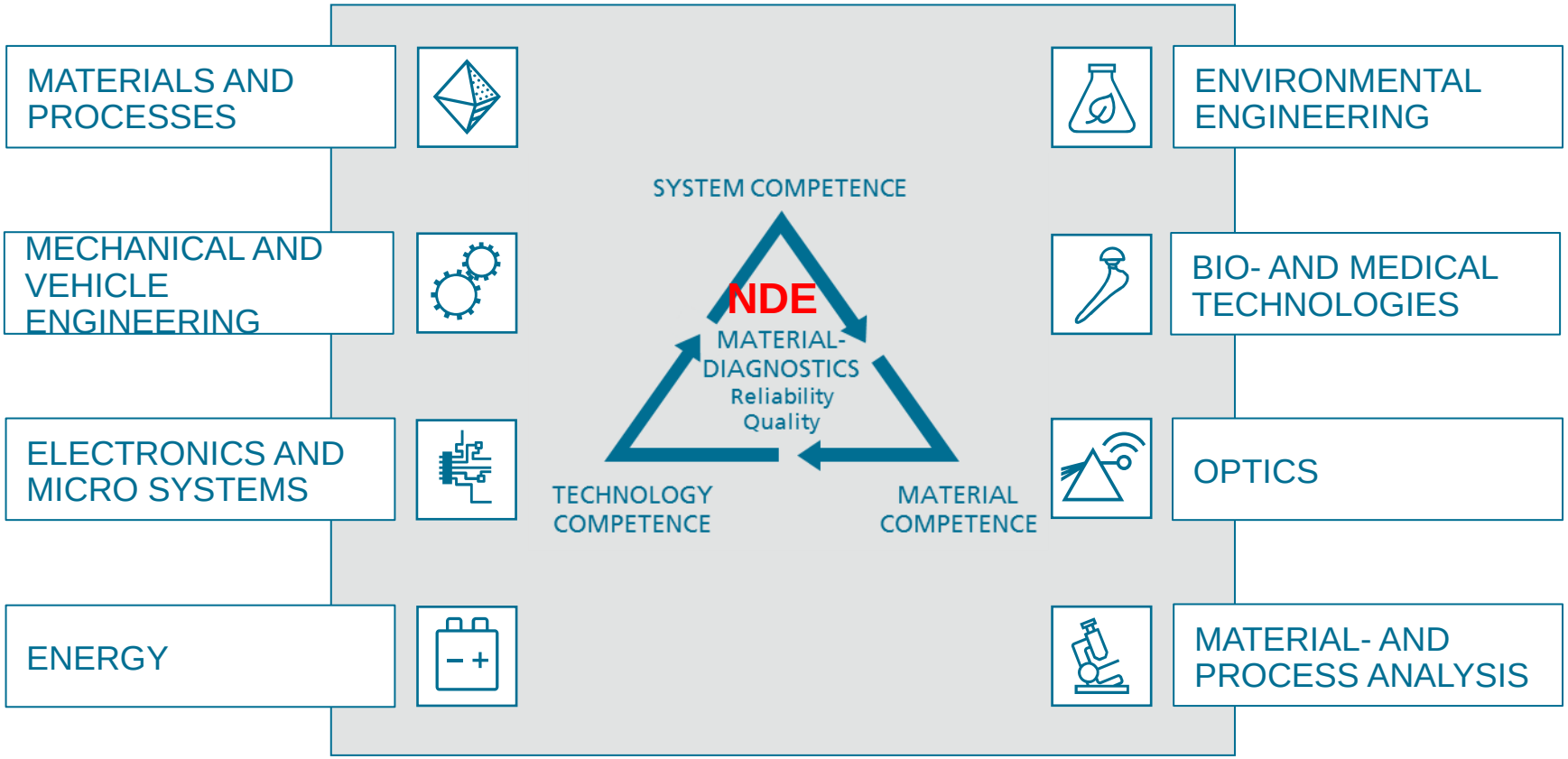
cost-reduction: factor 10



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Advanced Ceramics for product innovations at IKTS



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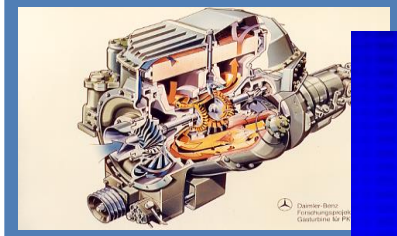
Backup

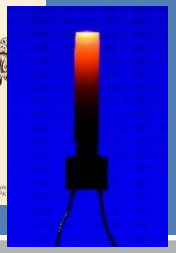
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Energy and Environmental Technology at IKTS



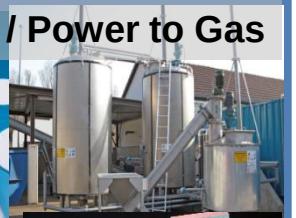
Ceramics for combustion engines and turbines





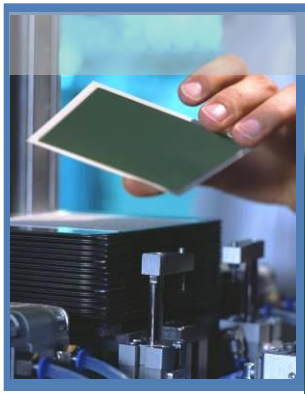
Membranes for Filtration Oxyfuel / Power to Gas





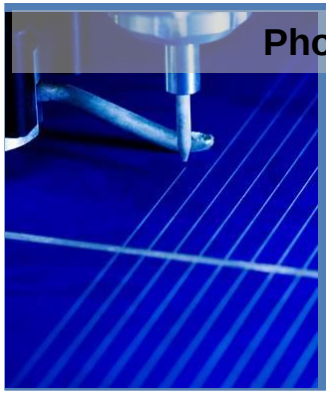


Fuel Cells

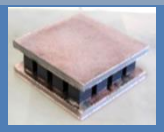


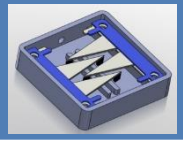


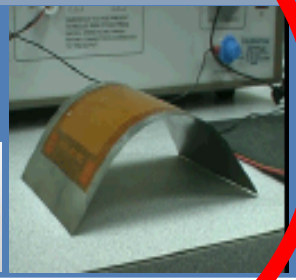
Photovoltaics



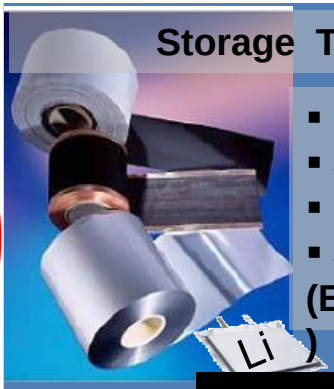
Energy Harvesting (Piezoceramics, TEG)



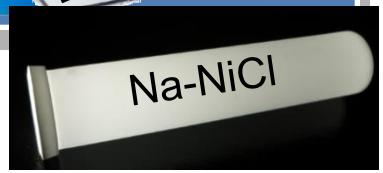




Storage Technology



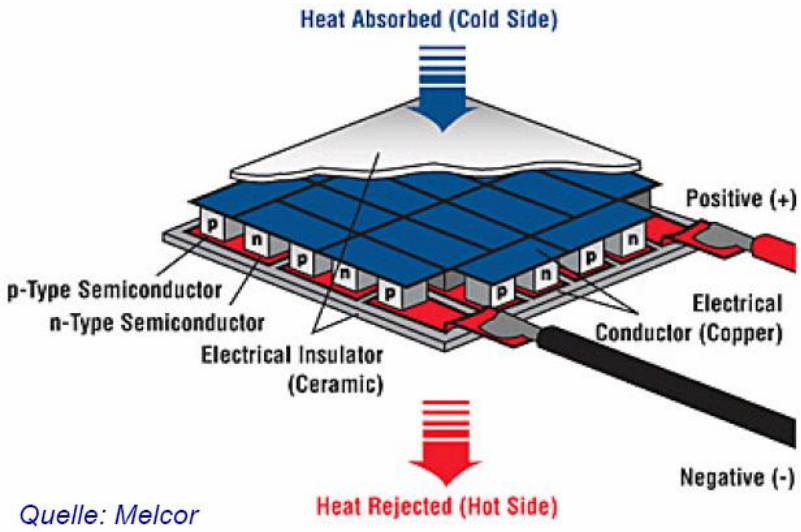
- Li-Battery
- Supercup
- Na-NiCl
- SOEC - (Electrolysis)



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TEG: state of the art (thermoelectric converters)





Bi_2Te_3 200°C

ZT 0,8….1,5

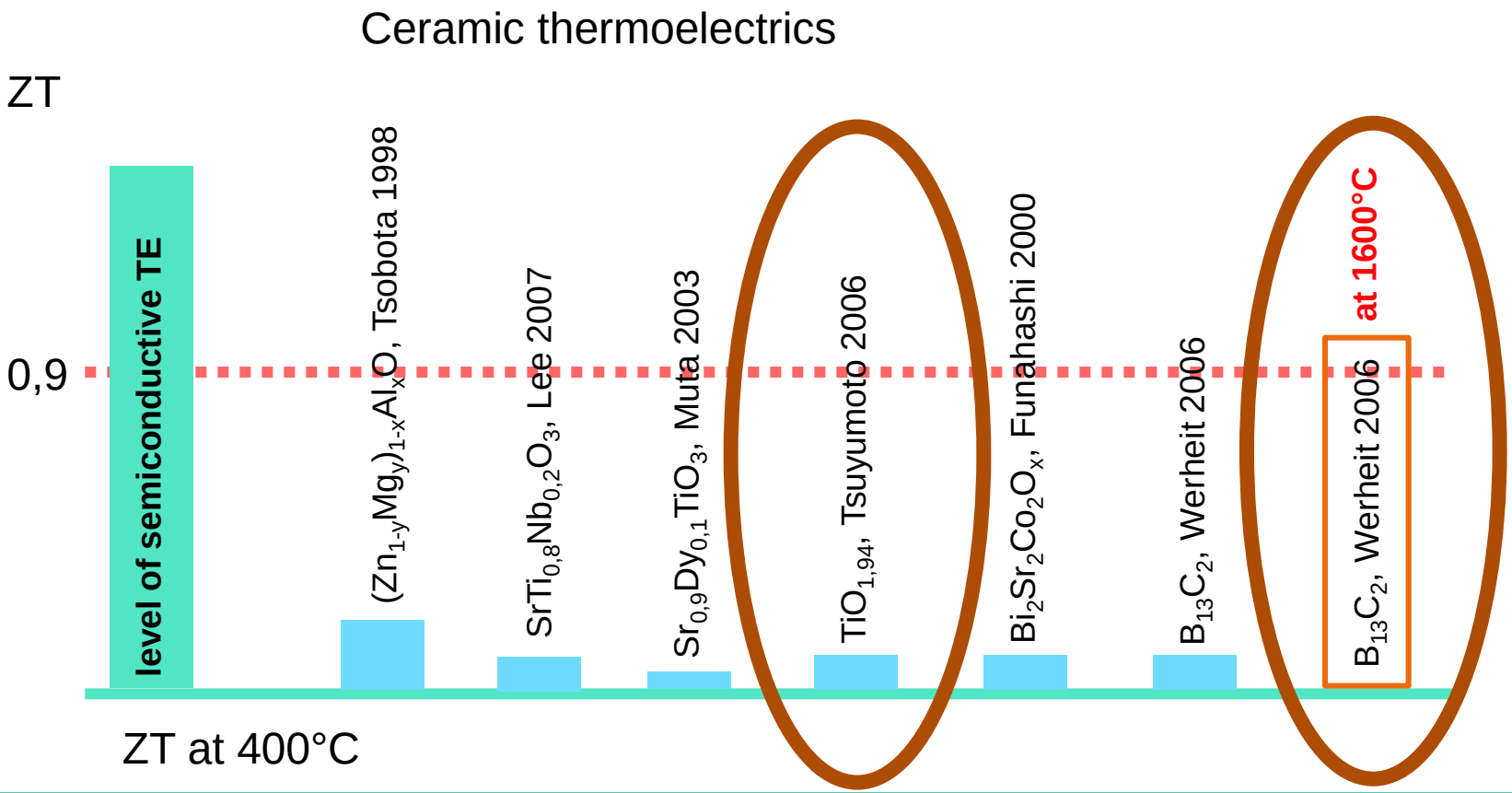
SiGe
PbTe 400°C

Skutterudite $(Co,Ni)Sb_3$

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some thermoelectric ceramic material candidates



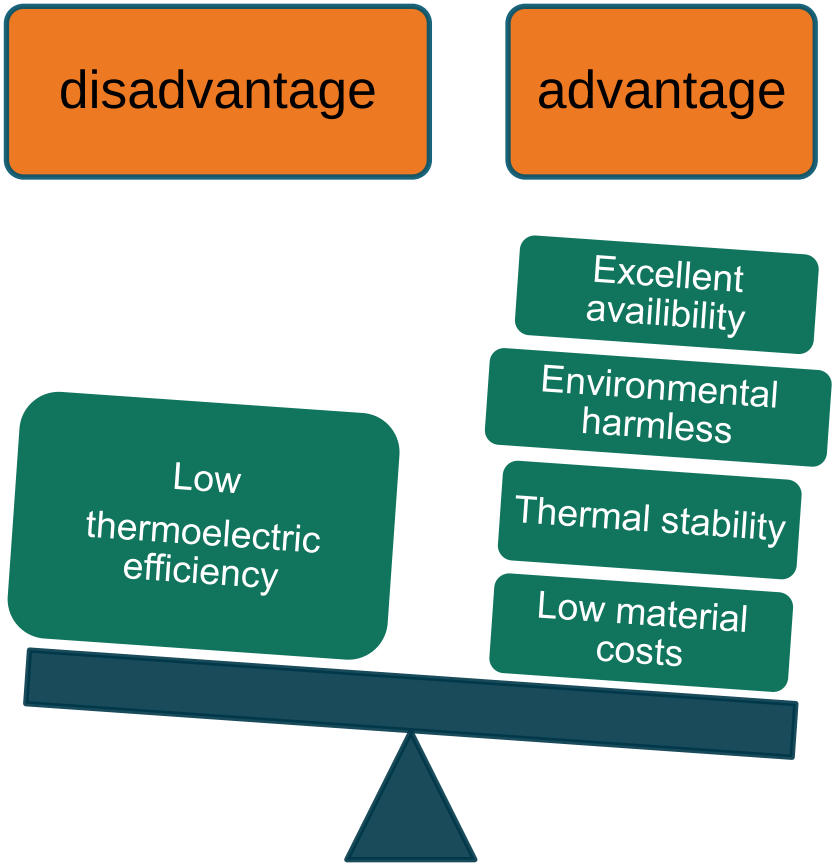
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Potential of ceramic thermoelectrics, TiO_x

$$ZT = \frac{S^2 \cdot \sigma}{\kappa} \cdot T_m$$



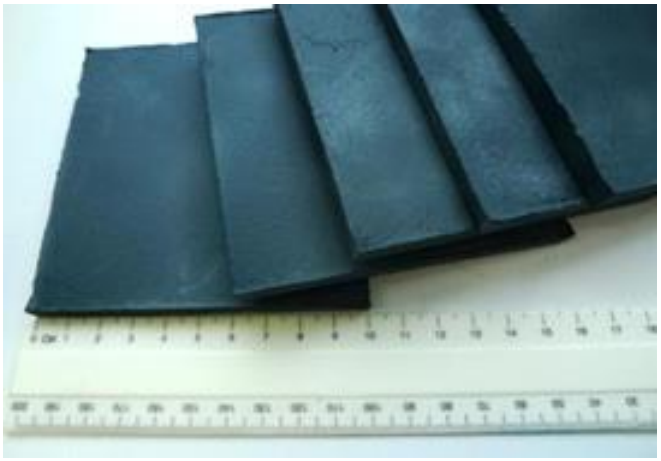
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Titanium suboxide as a thermoelectric material

- Why titanium suboxide?
  - Large quantities available
  - good chemical stability (except for oxidation)
  - Low costs compared to other thermoelectrics (< 20 €/kg, TiO_x)



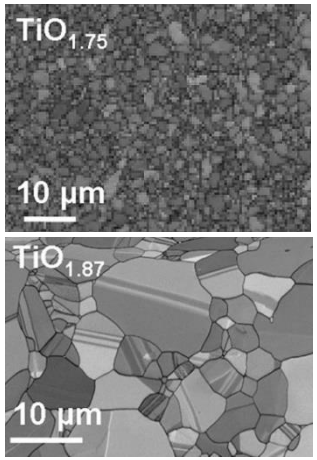




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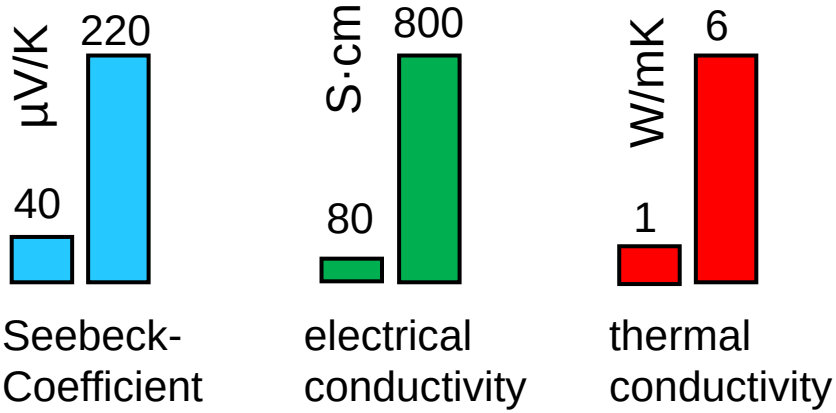
Titanium suboxide as thermoelectric material

- Thermoelectric potential of TiO_x?
  - Calculations for single phase Magneli phases predict ZT < 0.2 → confirmed
  - Nanostructure, mixed phases, composite (TiN,…) - effects ? ⇒ ZT 0.5…1 ?



M. Backhaus-Ricoult, J.Electr.Mat. 41 (2012)
DOI:10.1007/s11664-012-2019-4

TE data found experimentally



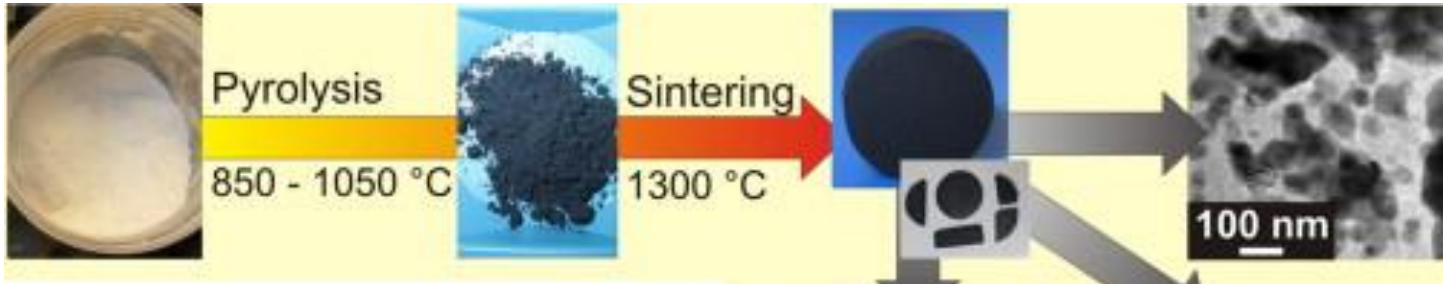
IKTS figures

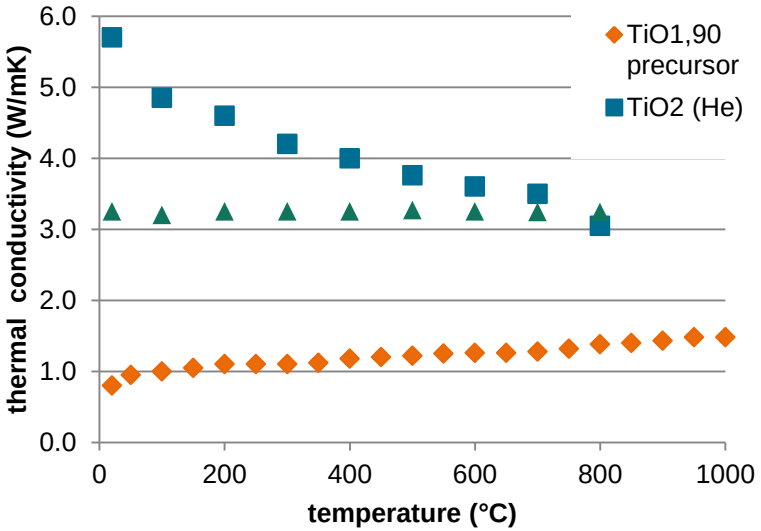
ZT range: 0.0016 … 2,3 ⇒ **reasonable ZT goal: 0.4** … 1.0

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precursor derived Ti-O for micro-structure optimization





bench mark process

for lowest thermal conductivity

Magnéli phases Ti_4O_7 and Ti_8O_{15} and their carbon nanocomposites via the thermal decomposition-precursor route

•S. Conze[a], , I. Veremchuk[b], M. Reibold[c], B. Matthey[a], A. Michaelis[a], Yu. Grin[b], I. Kinski[a], **Journal Solid State Chemistry 2015 (235)**

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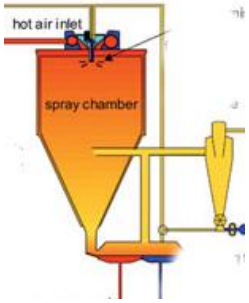
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TEG module fabrication by established (low cost) ceramic processing

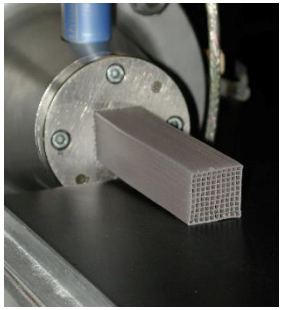
- Target process



material processing



manufacture of TE-legs

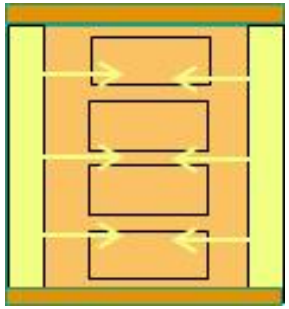


Cutting

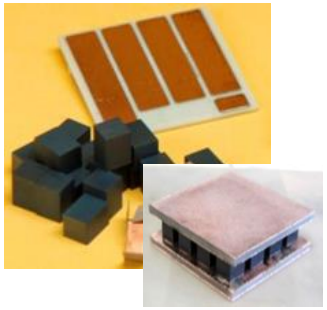


Oxidation protection

pressureless sintering



manufacture of modules



assembly technologies

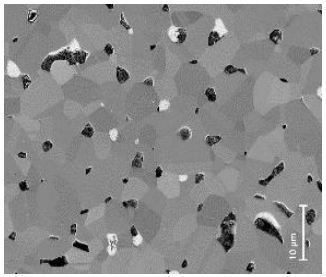
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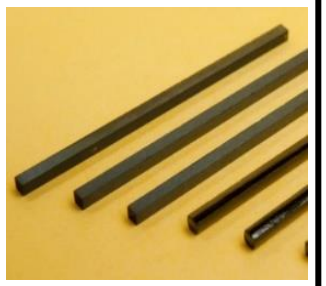
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TiOx thermoelectrical generators

Material development

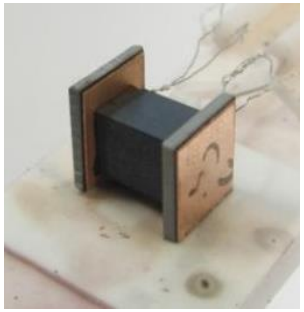
- Development of sintered TiO_x by different technologies
- **Reached maximum $ZT_{770\,°C}$ = 0,22**
- Upscaling of material production to ~ 100 kg TiO_x

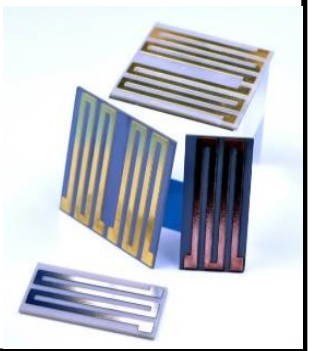




Assembley- and joining technology

- Low cost SiN substrates
- Oxidation protection for TiOx by glass coating
- low contact resistance by active filler brazing
- Metallization of substrates with Cu, Ni





Thermoelectric modules

- successful development of uni-leg modules
- Optimised process integration
- use of industrial components
- application testing ongoing







ICC6 August 21–25, 2016 (Dresden, Germany)

ICC6 International Congress on Ceramics
From Lab to Fab

August 21–25, 2016
Dresden, Germany, International Congress Center

Call for papers and posters



Deutsche Keramische Gesellschaft e. V.

Fraunhofer IKTS

International Ceramic Federation

Contact

Local organizing committee
Fraunhofer Institute for Ceramic Technologies and Systems IKTS
Winterbergstrasse 28
01277 Dresden, Germany
info@icc-6.com

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Please visit the conference website for detailed information on conference topics, call for papers and posters, sponsoring, registration, industrial exhibition, social program and accommodation.



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Co-chair

Prof. Dr. Jens Günster
Federal Institute for Materials
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Ceramic Processing and Biomaterials
Berlin, Germany



Important dates

December 16, 2015	Submission of abstracts
January 14, 2016	Notification of acceptance
March 10, 2016	Final program
June 20, 2016	Early bird registration
August 21–25, 2016	ICC6 takes place

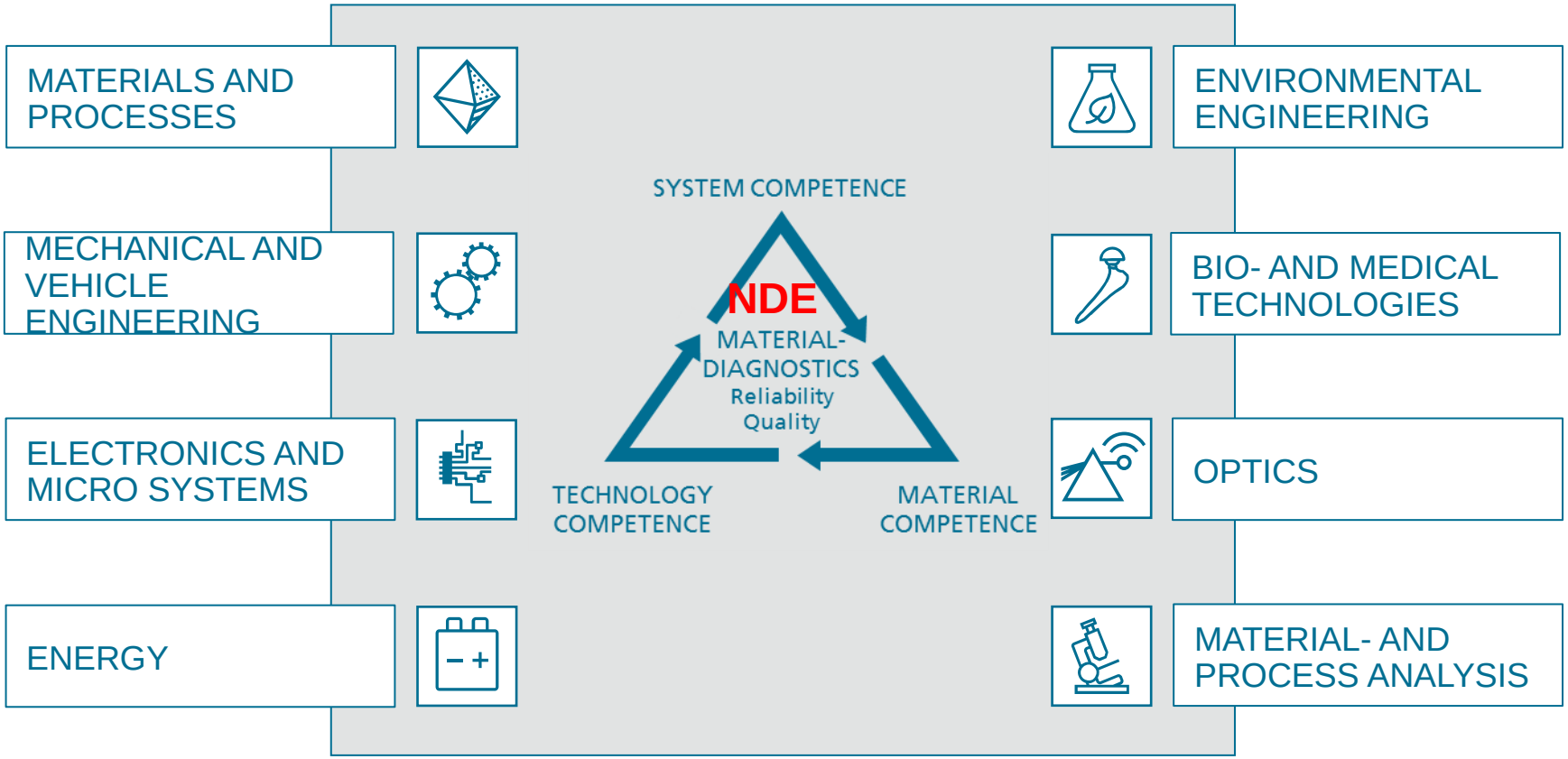
International Ceramic Federation

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Advanced Ceramics for product innovations at IKTS



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Backup

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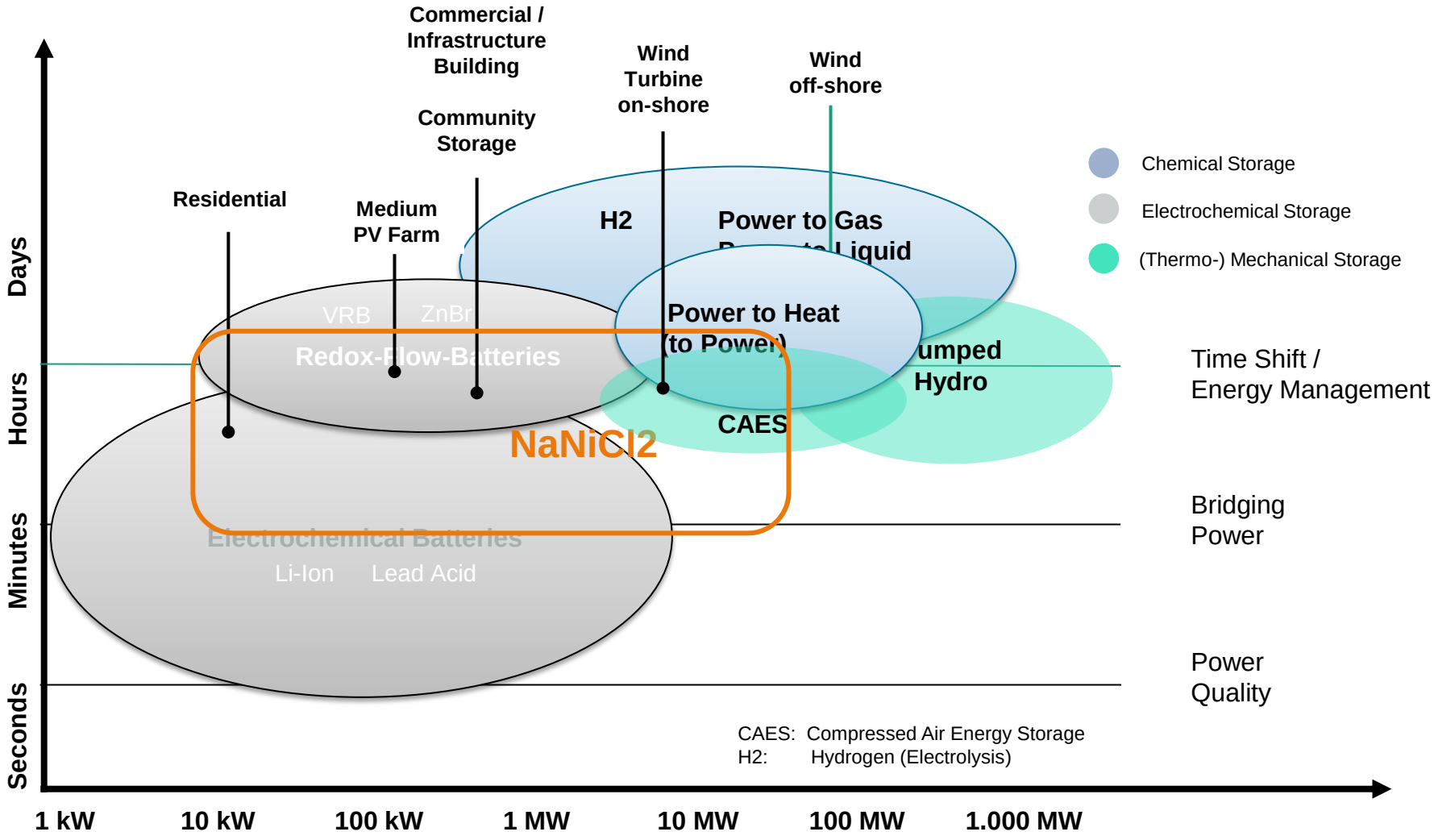
Co-Production of Renewable Hydrogen in California



- Site load ~ 6 MW; up to 300 kW provided from fuel cell
- Engines on biogas reduced from 13 MW to <4 MW – due to NO_x constraints
- Potential using biogas fuel cell: 20 MW + 20 MW of peak power and kVAR support

© 2012-14 FuelCell Energy Solutions GmbH

NaNiCl2 Batteries – Application range

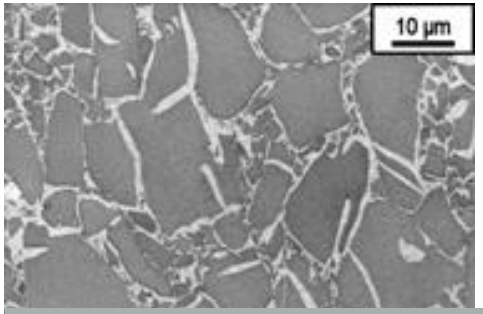


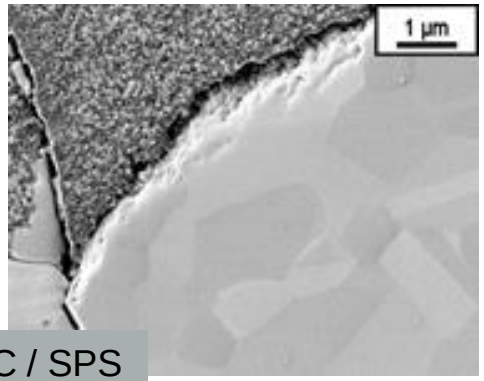
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Process optimisation

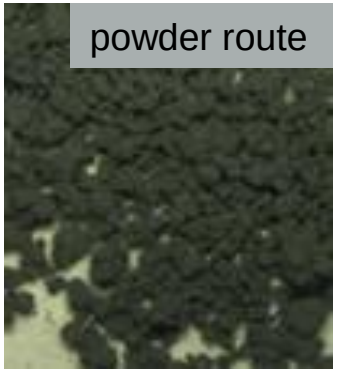
bench mark process for lowest thermal conductivity

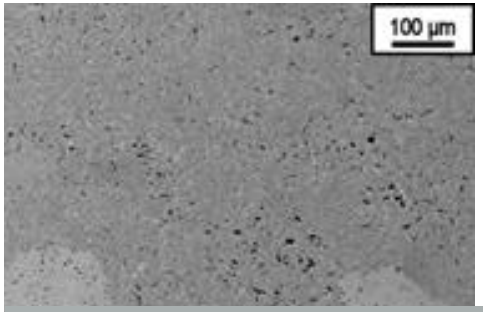


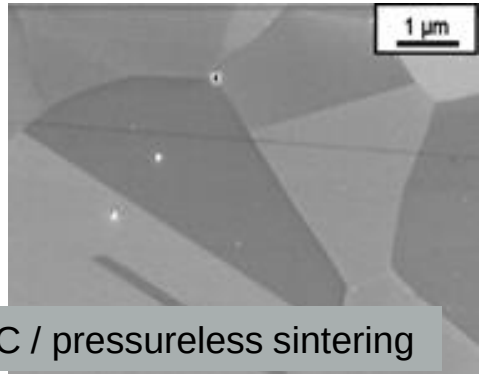




sintering temperature 1300°C / SPS







sintering temperature 1300°C / pressureless sintering

W/mK

1.5

κ

T= 300 K

no C contamination

2.5

κ

T= 300 K

low cost process → ZT ~ 0.2

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