BayFOR – INNOVIP – Building the Future 2020, 15.07.2020

“Open Innovation Test bed “LightCoce” – Project Overview and Brick Pilot Line at University of Applied Sciences Nuremberg”

Prof. Dr. Wolfgang Krcmar, Department of materials engineering
University of Applied Sciences Nuremberg

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12 Faculties of the TH-Nuremberg with 13.500 students

- Applied Chemistry
- Applied Mathematics and Physics
- Architecture
- Civil Engineering
- Business Administration
- Design
- Electrical Engineering
- Computer Science
- Mechanical Engineering
- Social Sciences
- Supply Engineering
- **Materials Engineering**

In addition to the Bachelor's program, the faculty "Materials Engineering" offers the postgraduate Master’s program "New Materials, Nano- and Production Technology"

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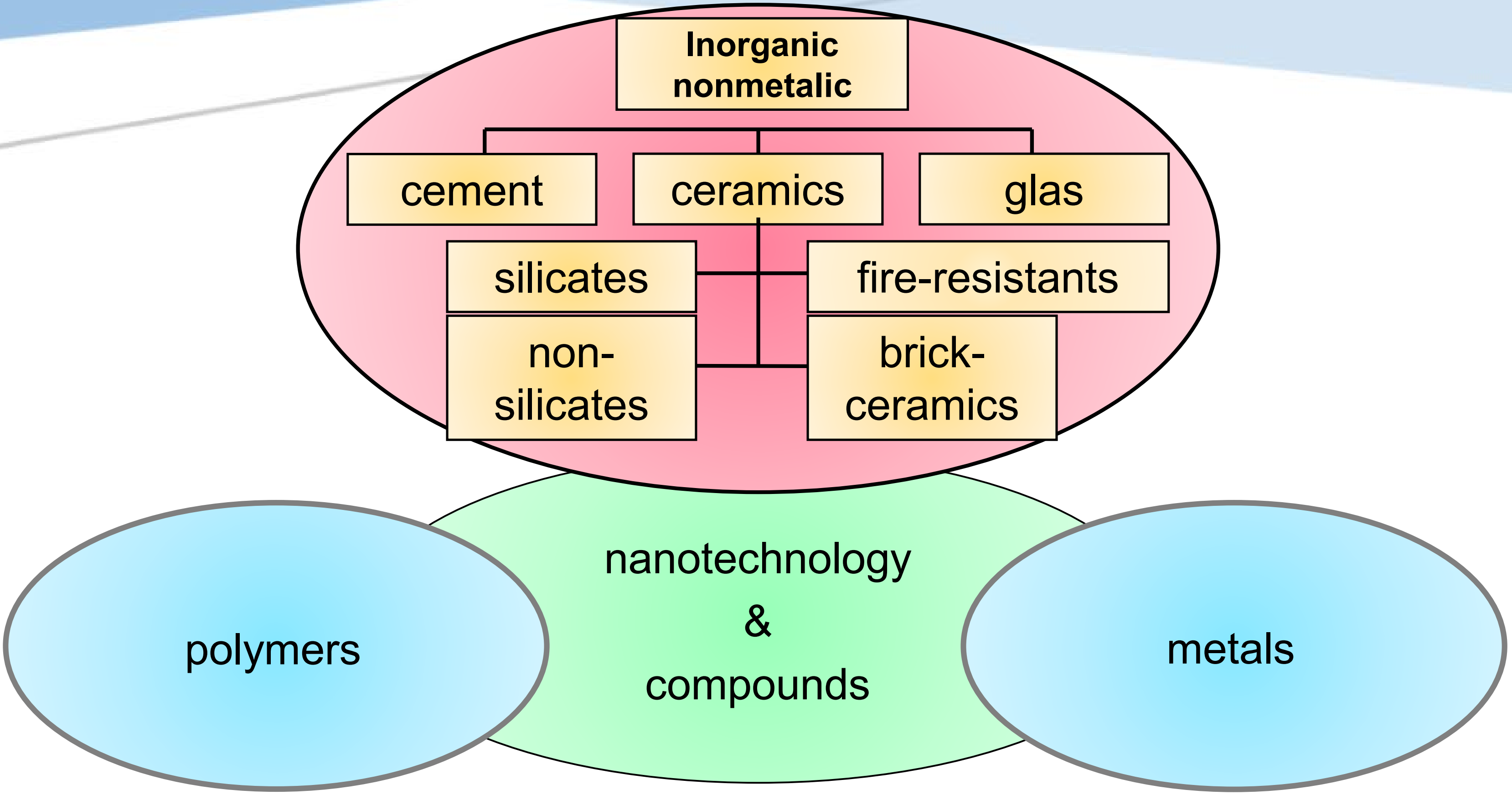
Fields of teaching and research at the faculty of materials engineering

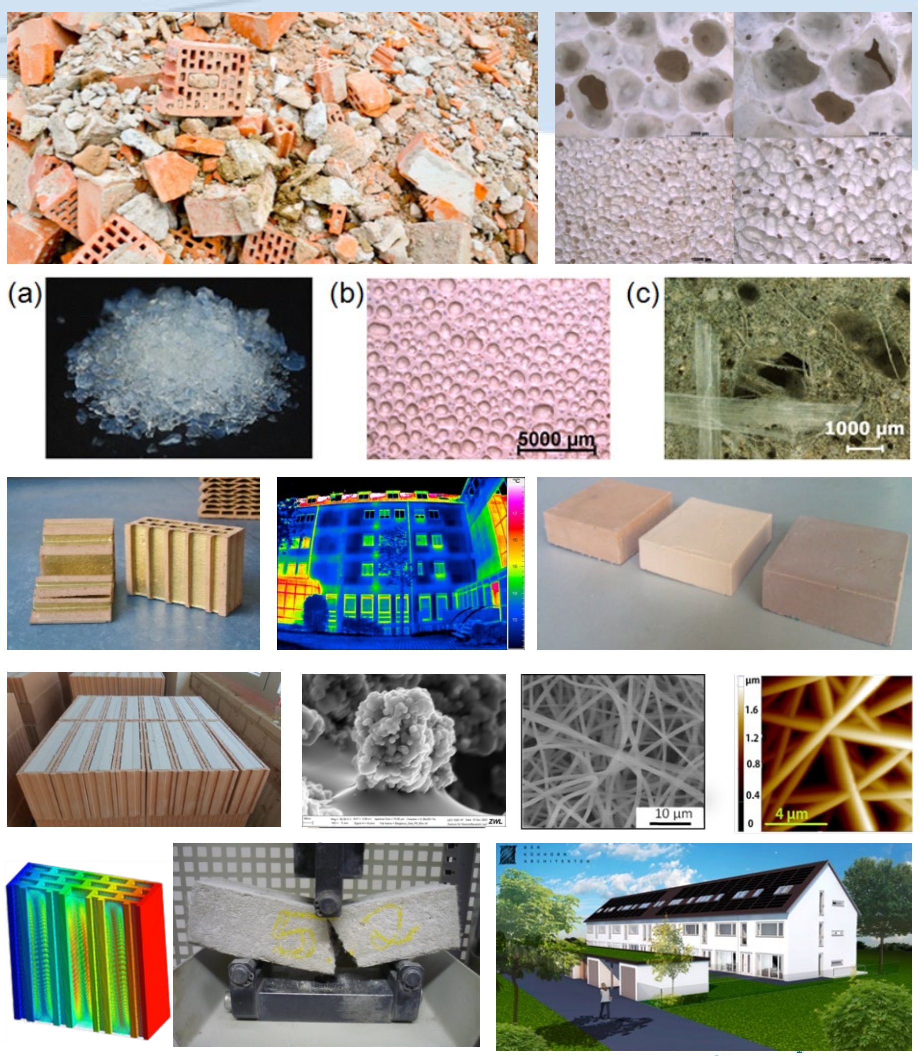


Bachelor-course + Master-course: 450 students

Work group of Prof. Dr. Krcmar - Energy efficient building materials

Fields of activities

- Highly heat-insulating building materials
- Bricks
- Mortar, thin-layer mortar, plaster
- Geopolymers
- Insulating materials (Nanofibers + Aerogels)
- Construction of energy-efficient buildings
- Energy-efficient building facades
- Recycling of building materials
- Heat-insulating coatings
- (Easy-to-clean-effect on building materials)
- FEM-simulations (heat- & noise insulation)
- Different laboratory testings
- Building-projects



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EU - project „LightCoce“; Horizon 2020: Foundations for tomorrow`s Industry

Common subject: "Research and development of new lightweight materials”

- Concrete
- Conventional ceramics (Bricks, Tiles)
- Advanced ceramics

Goals

- Development of new, lightweight materials with multifunctional properties
- High mechanical strength and improved thermal insulation
- Integration of nano-materials
- Cost reduction of production and transport
- Setup of 5 pilot plants (Test-bed`s)

Participants: 26 Partners from 9 EU member states
Total financial budget: € 13.48 million
Project duration: 4 years

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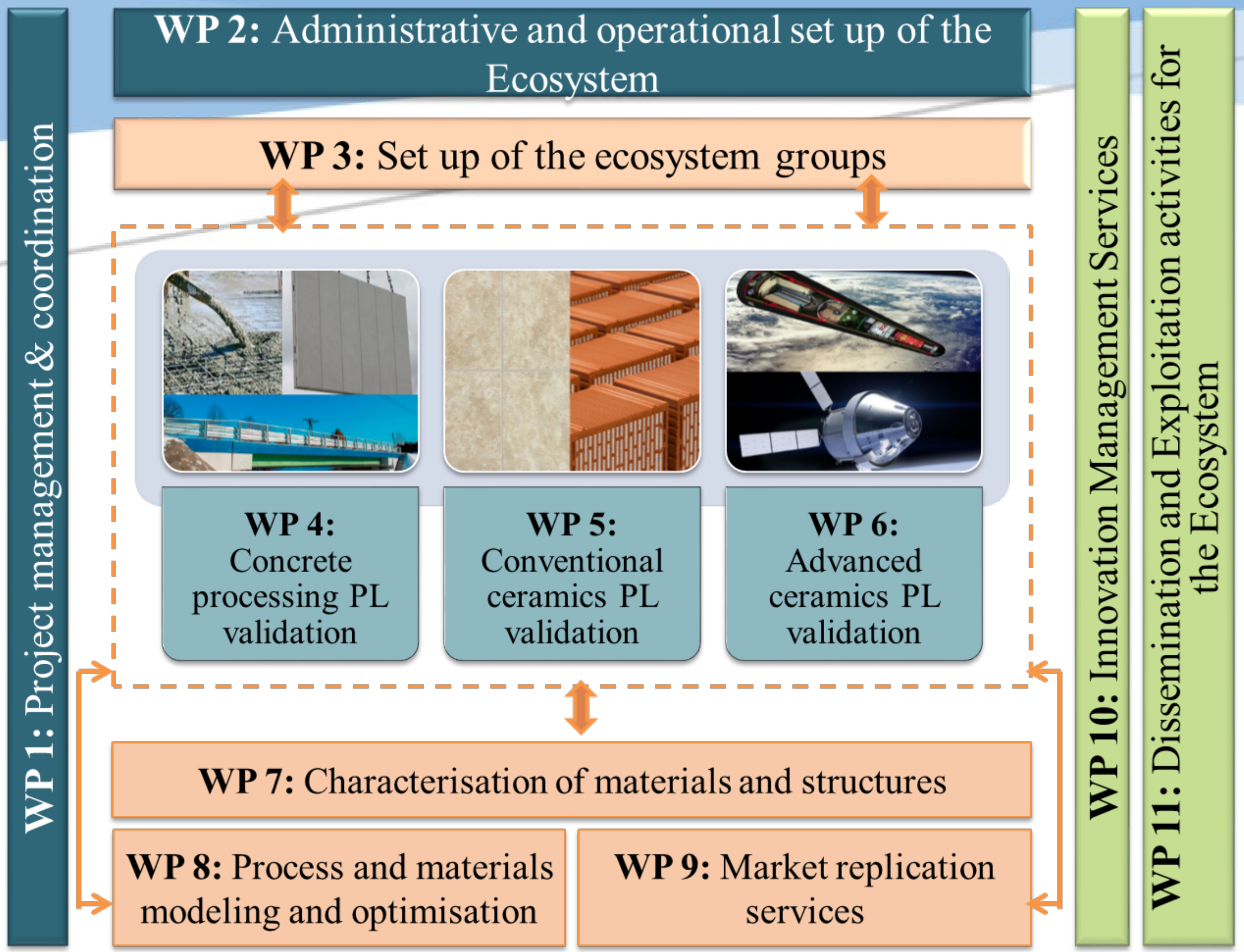
Overview of the setup of 5 pilot plants



Setup of 5 pilot plants

WP 4: Concrete

Sweden; RISE and Greece, NTUA

WP 5: Conventional Ceramics

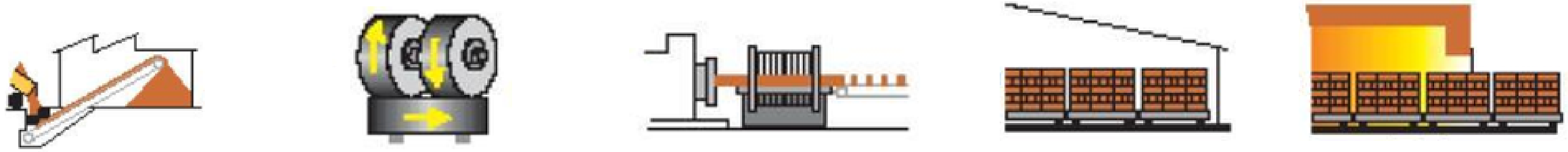
Tiles: Spain; ITC
Ziegel: Germany, THN/EnCN

WP 6: Advanced Ceramics

Poland; INOP

Brick pilot line process overview

Crushing Grinding → Mixing → Extrusion → Cutting → Drying → Firing → Cooling



Storage → Milling and Grinding → Forming and Cutting → Drying → Firing → Materials testing & Analytics

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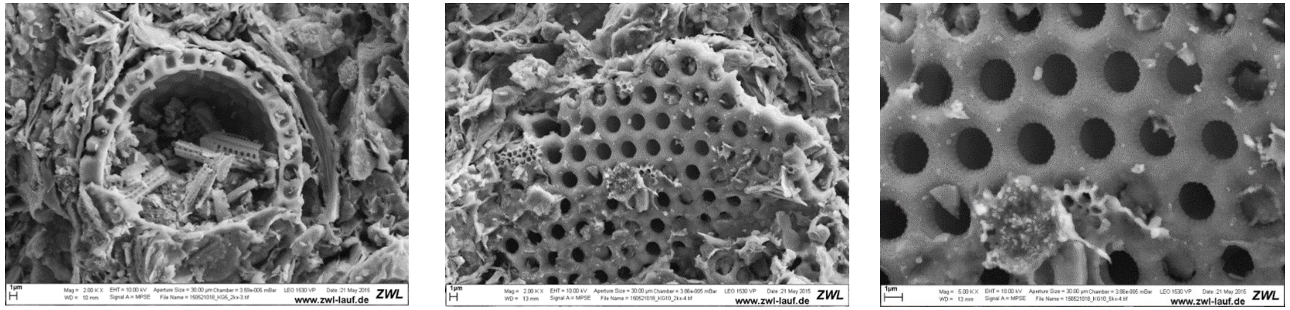
"LightCoce" - Test case for THN pilot line
Extrusion of lightweight bricks with nano porosifying agents

Lightweight bricks with the following characteristics will be produced:

Property	State of the art	Goal
Ceramic density ρ [kg/dm^3]	1,5	≤ 1,0
Thermal conductivity $\lambda_{10,dry}$ [W/mK]	0,35	0,25



REM-pictures: 2.000 x 5.000 x

Strategy:

- ➢ Excessive aging of clay ("Mauk"-Effect)
- ➢ Addition of organic porosifying agents: organic opening materials (e.g. carbon black)
- ➢ Addition of inorganic porosifying agents: kaolin, diatomaceous earth and pyrogenic silica

Advantages of the lightweight bricks:

- ➢ Lower consumption of primary fuels for heating buildings (reduced CO_2 emission)
- ➢ Reduction in fuel consumption for firing of bricks
- ➢ Reduction in transport costs due to lighter products

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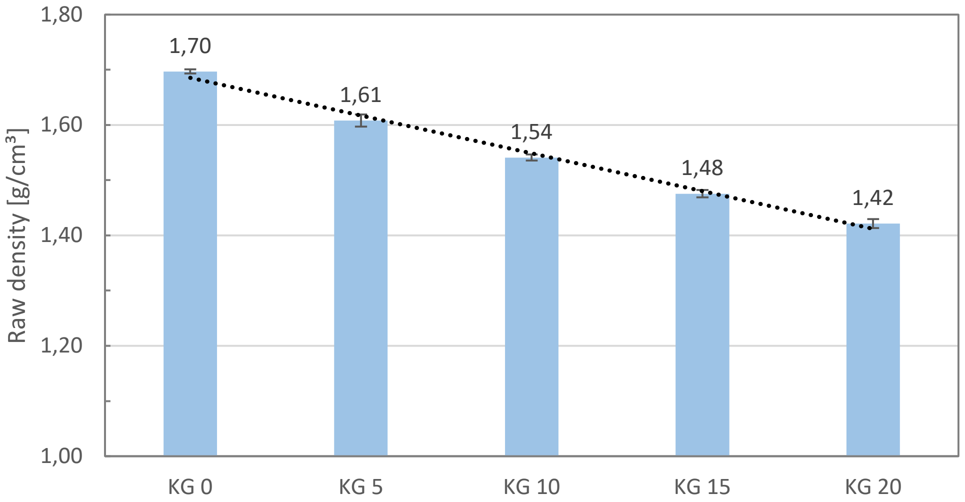
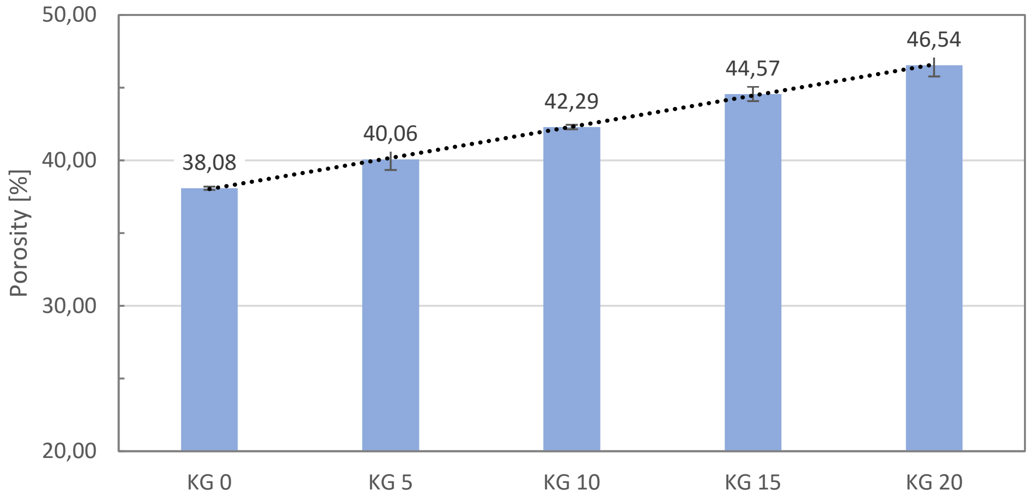
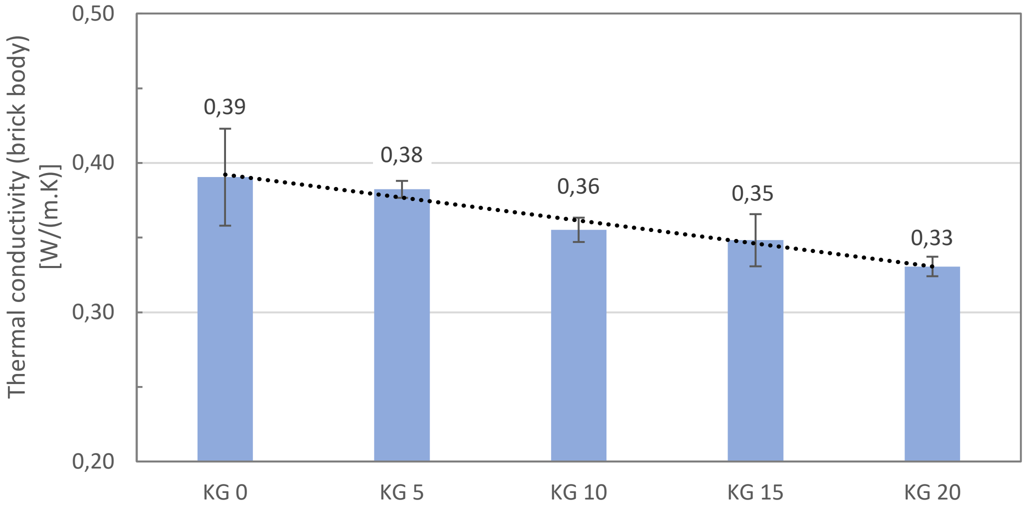
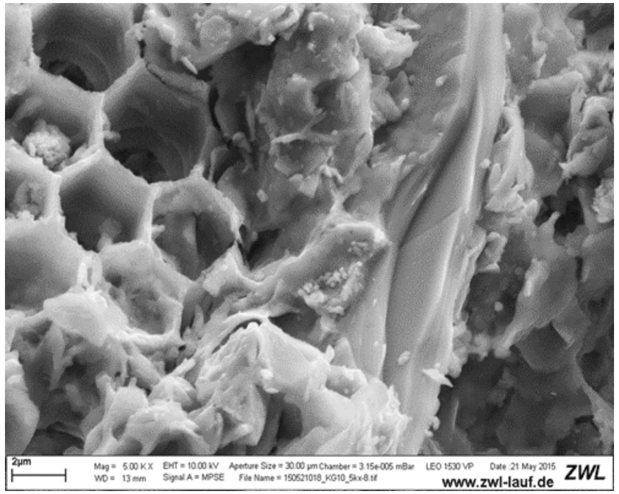
“LightCoce”: Extrusion of lightweight bricks with diatomaceous earth

Brick – clay with 5, 10, 15 and 20 ma.-% diatomaceous earth









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EU-Project “LightCoce”: 2nd plenary session at the Energy Campus Nuremberg at 14./15.01.2020 with 50 participants from 9 European countries

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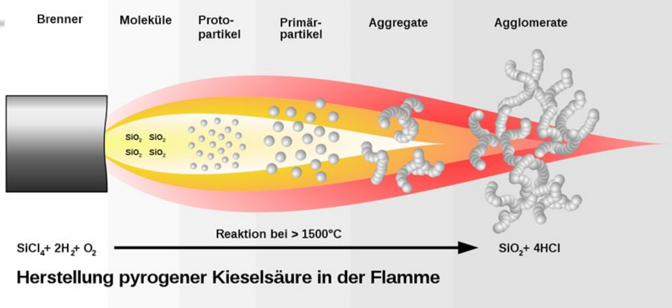
Example 1: Herzo Base energy-storage buildings with Energetic standard KfW 40 Plus

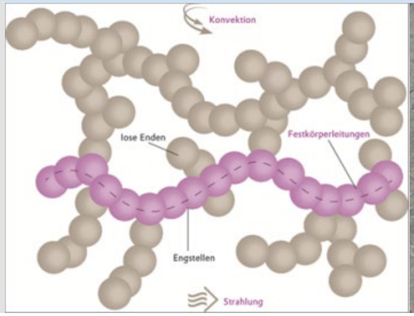
Application of the highly insulating material „CALOSTAT“ (silica fume SiO_2) in wall-bricks

Properties of CALOSTAT

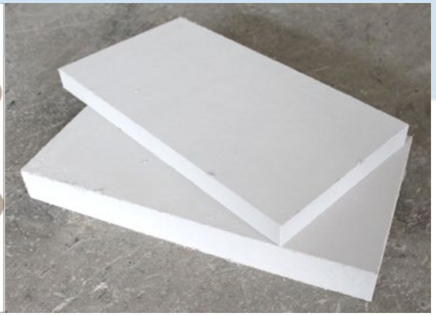
- Diffusion coefficient μ = 6
- Hydrophobe; no water-absorption
- Minerally; incombustible
- Thermal conductivity $\lambda_{10,\ dr.}$ = 0,019 W/(m*K)



Nanostructure



CALOSTAT



Brick-envelope
$\lambda_{equiv.}$ = 0,345 W/(mK)

Perlite-brick
$\lambda_{equiv.}$ = 0,071 W/(mK)

CALOSTAT-bricks
$\lambda_{equiv.}$ = 0,046 W/(mK)

Perlite-brick
$\lambda_{equiv.}$ = 0,07 W/(mK)

CALOSTAT- brick
$\lambda_{equiv.}$ = 0,041 W/(mK)

Improvement of the thermal insulation: 35 %

Improvement: 41 %

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

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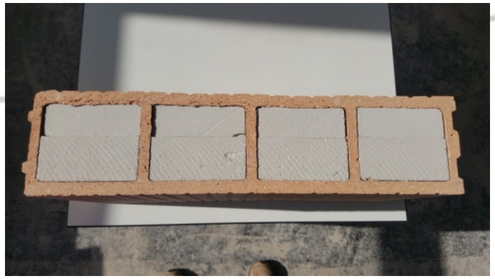
Example 1:
Herzo Base energy-storage buildings with Energetic standard KfW 40 Plus
Application of the highly insulating material „CALOSTAT“ (silica fume SiO_2) in wall-bricks

Contruction of 8 terrace houses

Production of 2000 pieces

2 houses: Perlite-bricks, Wall thickness 42,5 cm: U-value = 0,15 W/(m^2*K)

2 houses: Perlite-bricks, Wall thickness 36,5 cm: U-value = 0,18 W/(m^2*K)

4 houses: Perlite-bricks, Wall thickness 30,0 cm + 12 cm CALOSTAT-brick: **U = 0,13 W/(m^2*K)**




Outer plaster λ = 0,17 W/(m*K)
Solarpainting

Inner plaster: λ = 0,18 W/(mK)

Gefördert durch:
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Example 1:
Herzo Base energy-storage buildings with Energetic standard KfW 40 Plus

Plan of the architect

Groundbreaking 14.07.2016

End of November 2016

Roofing Ceremony 02.12.2016

March 2017

Rear View Energy Storage Houses
Nov. 2017

Frontside 2019

Gefördert durch:
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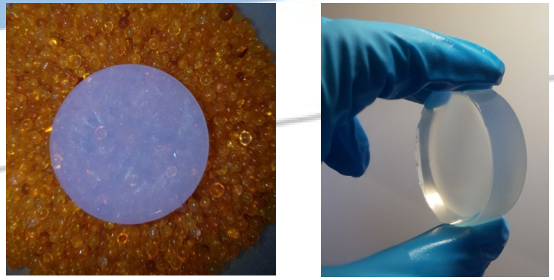
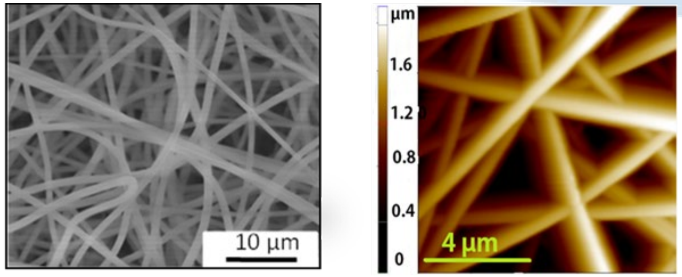
Example 2: SiO_2 – aerogel foam as insulation material

- Thermal conductivity of silica aerogel zero samples: 0,023 W/mK
- Thermal conductivity of fiber-modified silica aerogels: 0,021 W/mK

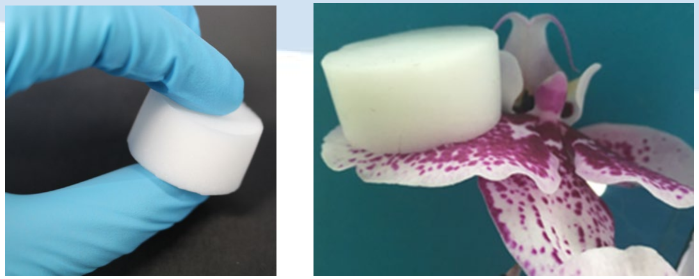


Aerogel zero sample

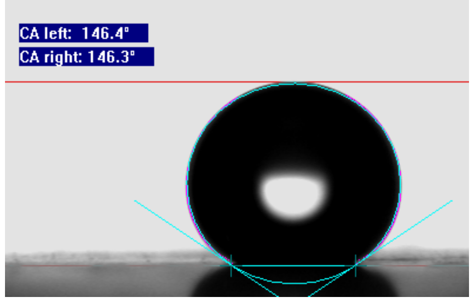
SiO_2 - Aerogel
$\lambda_{10,tr.}$ = 0,023 W/(m*K)

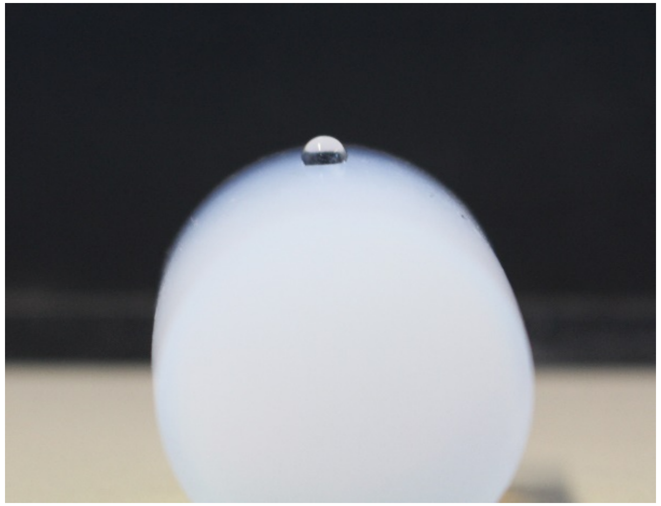


Polystyrene nanofibers
$\lambda_{10,tr.}$ = 0,01 W/(m*K)



Modified silica aerogel





Distinctive hydrophobicity: contact angle with "sessile drop" method > 145°

Filling of wall building materials

Nanofiber fleece

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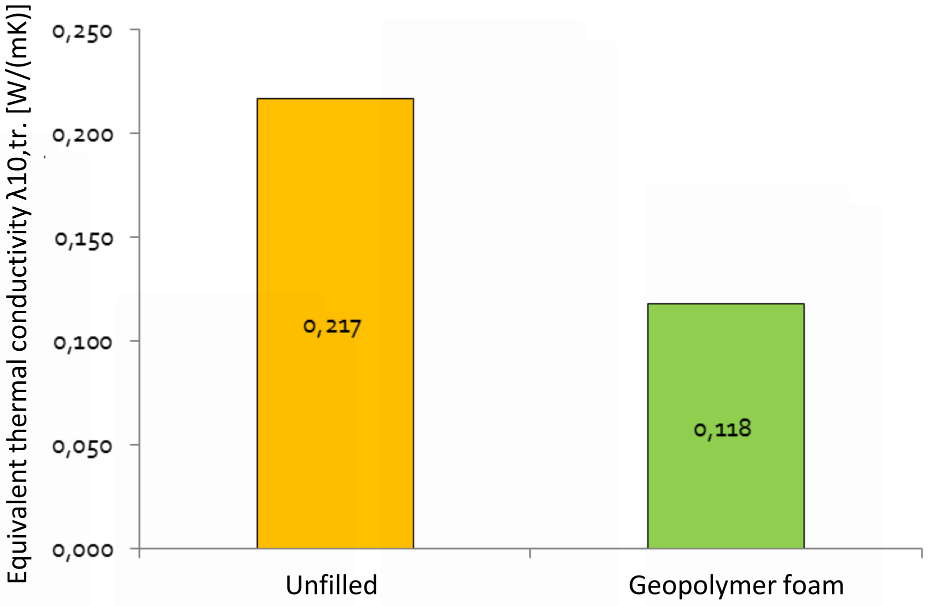
Example 3: New building and insulating materials from geopolymers

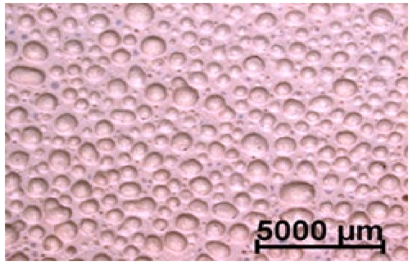
$$0{,}5\ (Al_2O_3 \cdot 2\ SiO_2) + 2\ Na^+ + 2\ OH^- + 2{,}5\ H_2O \rightarrow 2\ Na^+ + (HO)_3SiO^- + [Al(OH)_4]^-$$

1. High strength geopolymers

Compressive strength
ß = < 120 N/mm²



2. Foamed geopolymers



Compressive strength
ß = 2 N/mm²
$\lambda_{10,tr.}$ = 0,06 W/(m*K)

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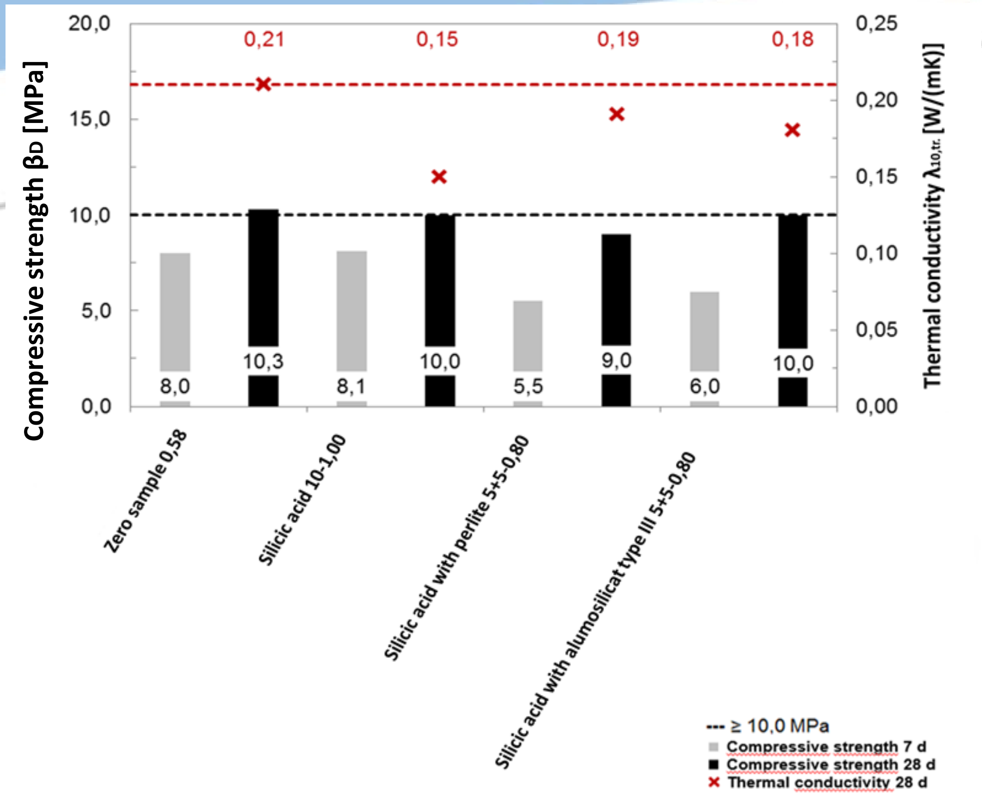
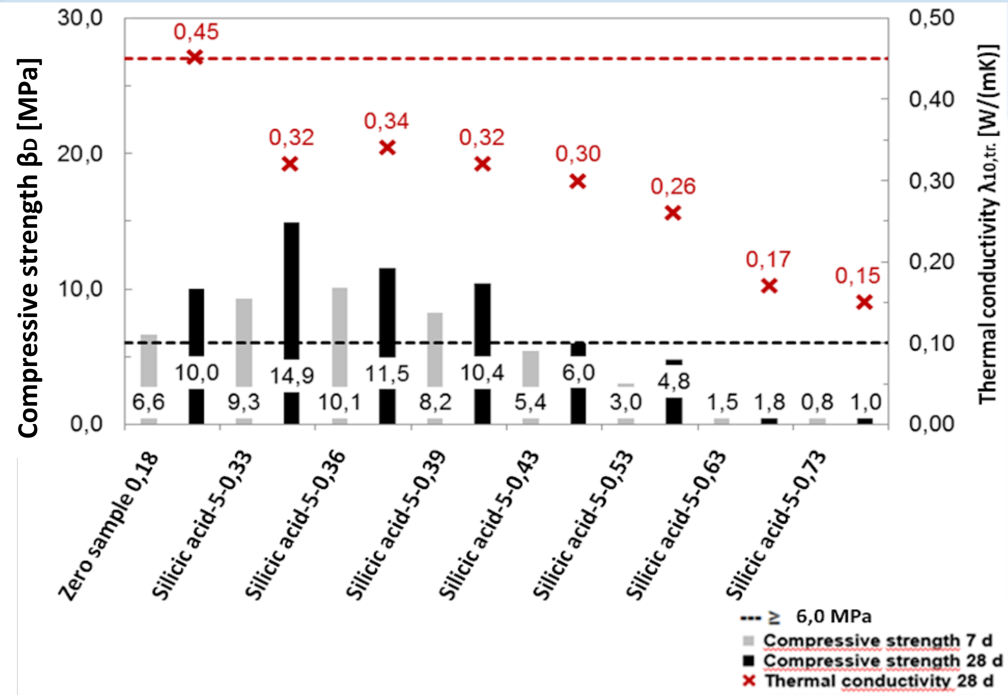
Example 4: Improvement of thermal insulation of thin-bed mortar and base plaster

Thin-bed mortar with fumed silica



Base plaster with fumed silica



- ➢ Reduction of thermal conductivity by almost **29,0 %**
- ➢ Compliance with the specified compressive strength class M 10

- ➢ Reduction of thermal conductivity by almost **29,0 %**
- ➢ Simultaneous **49 %** increase in compressive strength

Thank you for your attention !

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