Glass fiber reinforced hollow silica nanospheres for thermal insulation applications

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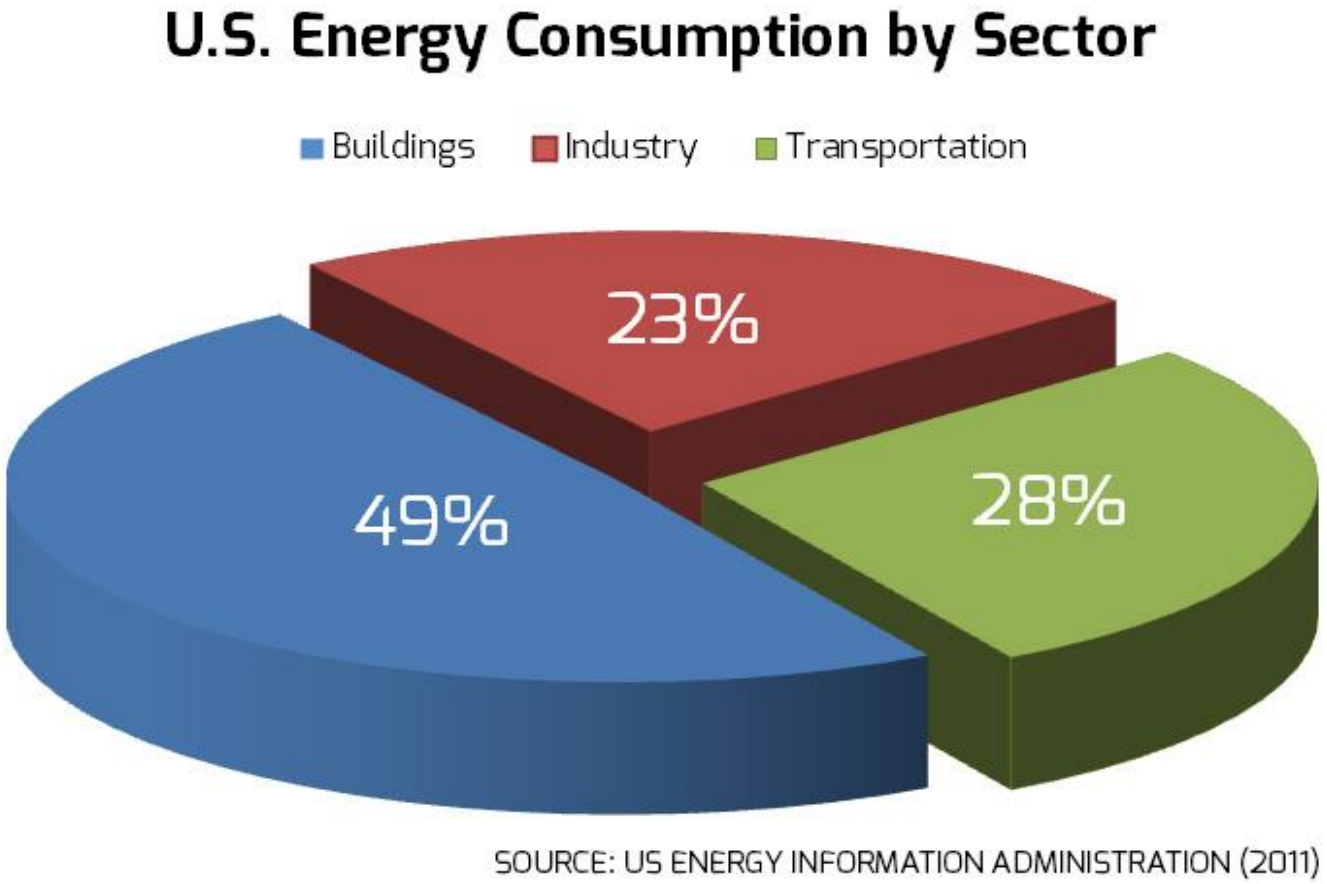
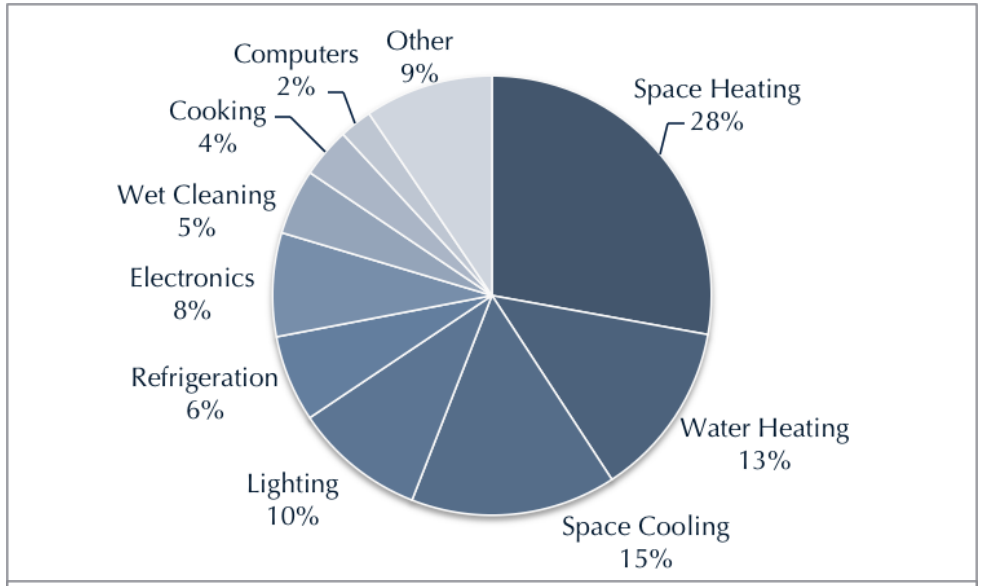
Outline

- **Background**
  - *Buildings & energy efficiency*
  - *Superinsulation materials/solutions*
- **Nano insulation materials**
  - *Silica aerogels*
  - *Hollow silica nanospheres (HSNSs)*
- **Fiber reinforced HSNSs**
  - *Synthesis*
  - *Properties*
- **Conclusions**

Energy & buildings



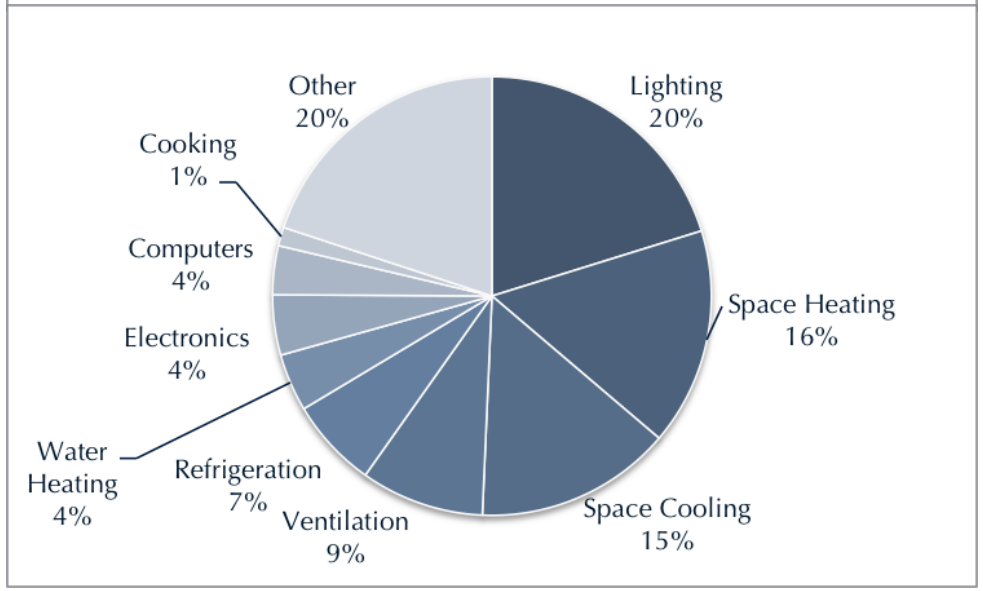
Energy use in buildings



Residential Buildings

Primary Energy End

Use Splits (2010)



Commercial Buildings

Primary Energy End

Use Splits (2010)

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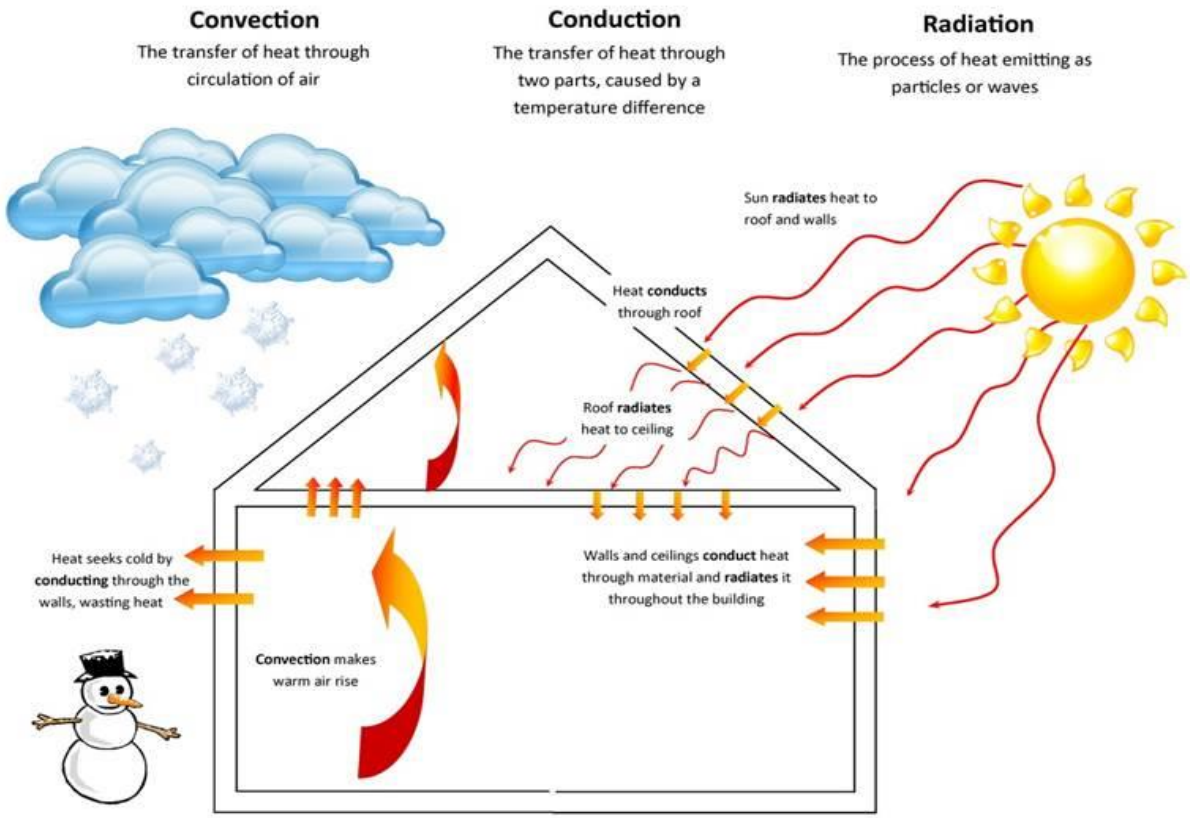
Factors influencing the energy use

Energy transfer through the building envelope

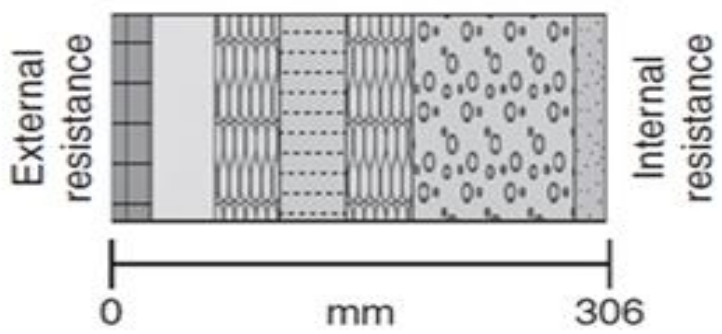


It is important to improve the energy performance of building envelope (wall, window, roof, etc.).

Thermal insulation is very important !

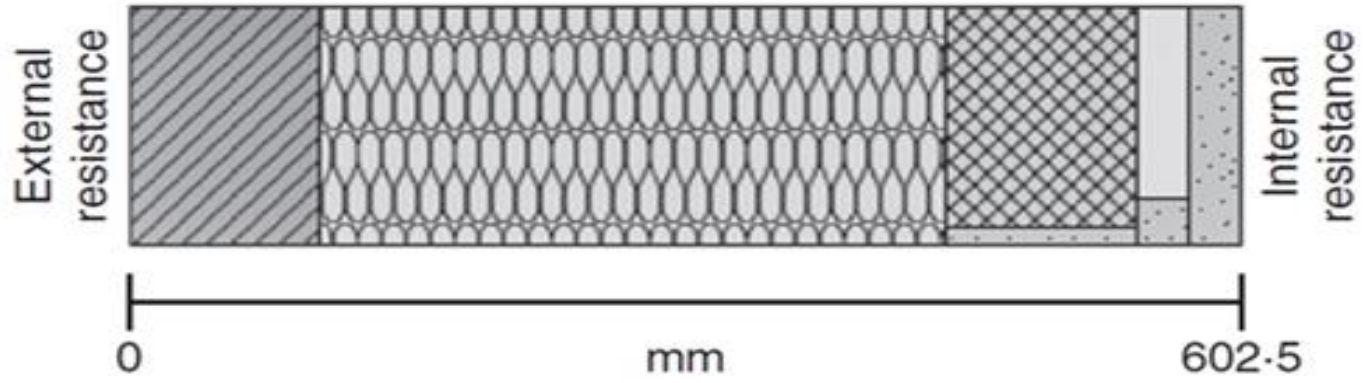
Thermal insulation materials/components are critical to building's energy efficiency

Thermal insulation materials/solutions



U-value: **0.1** W/m^{2}K

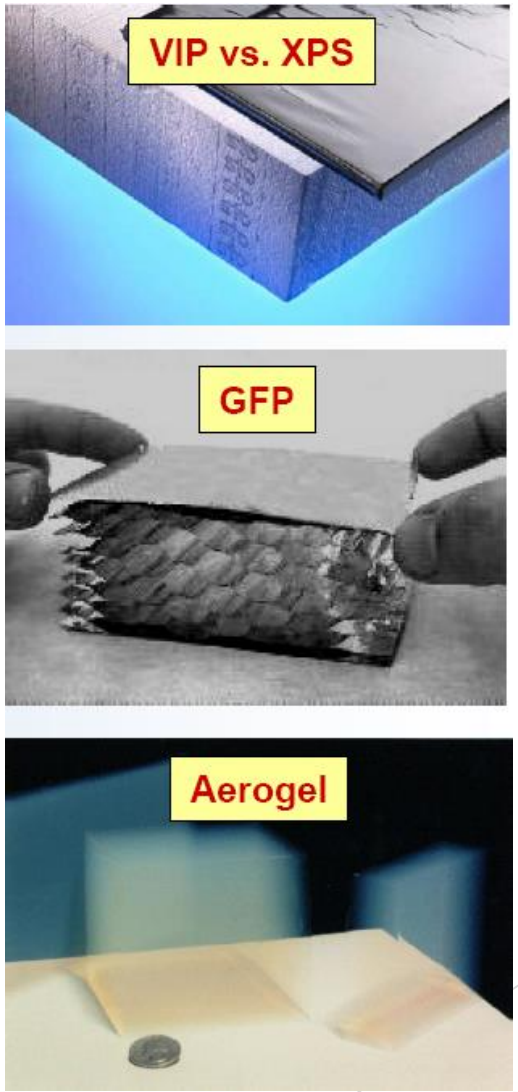
Stone facade panel; well-ventilated air gap; low-lambda EPS; VIP; low-lambda EPS; solid concrete wall; plaster



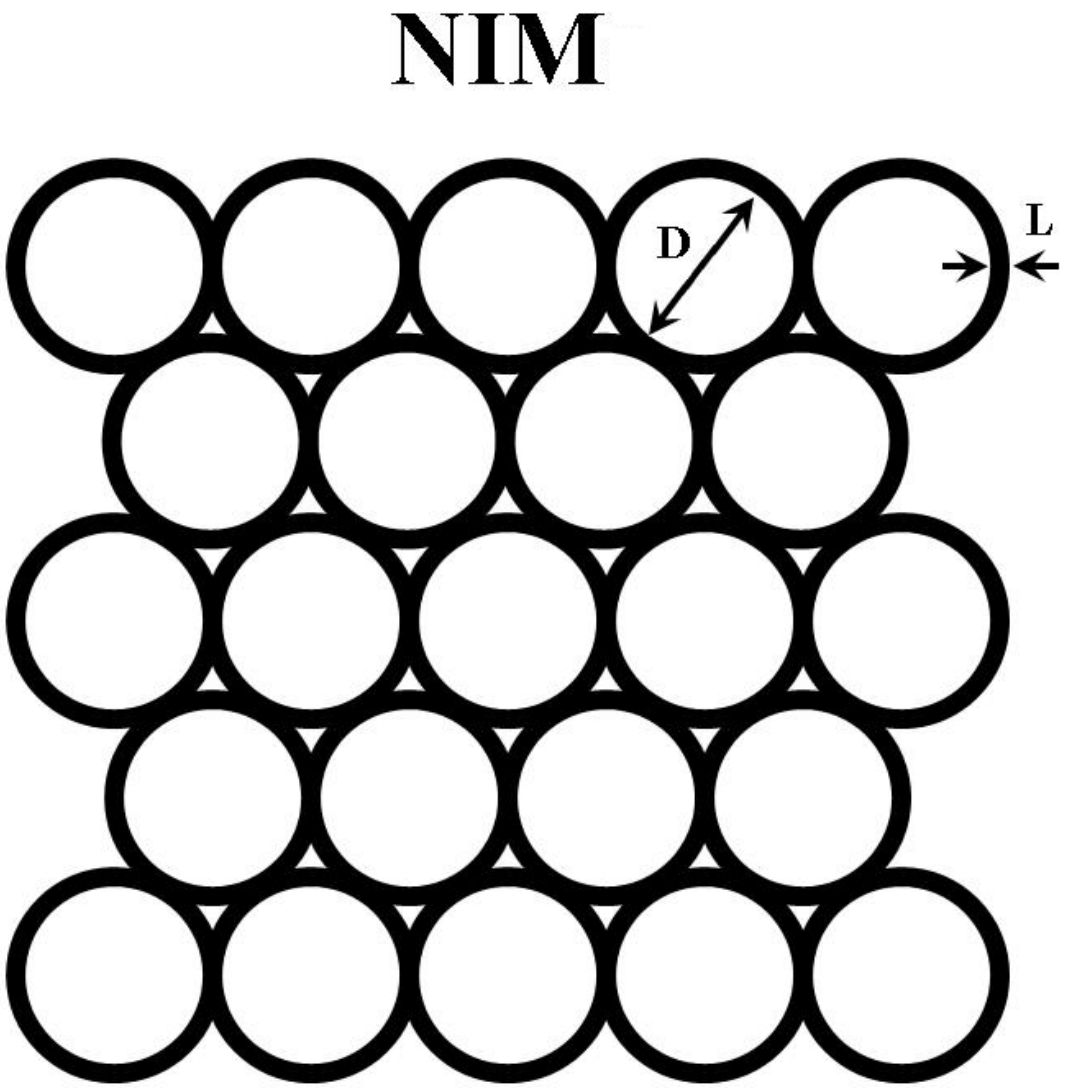
Brickwork; mineral wool insulation; lightweight blockwork; cavity + dabs; plasterboard

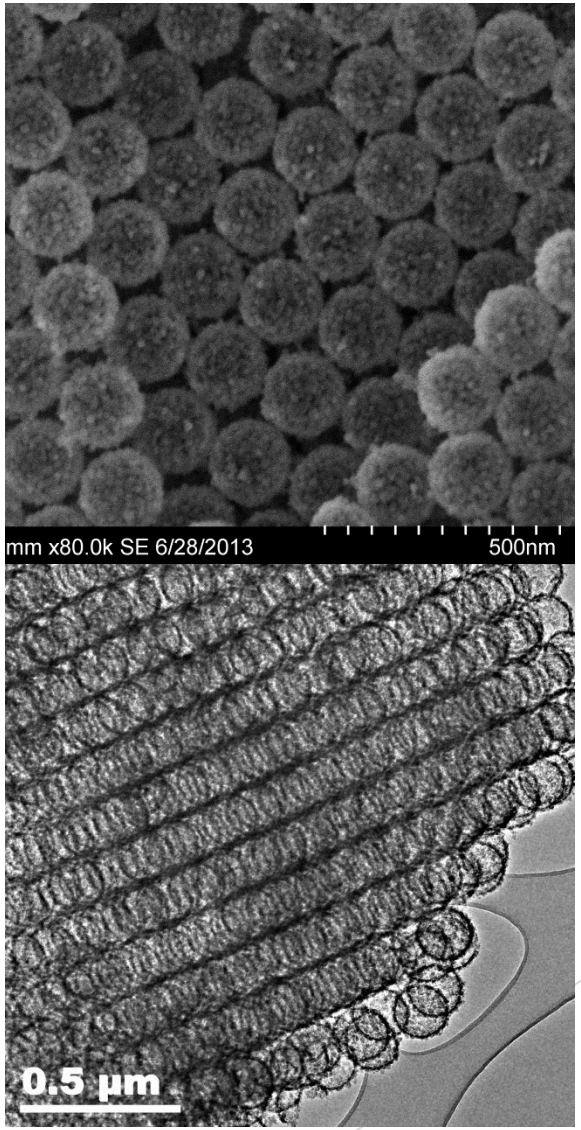
Thermal insulation of today

- **Traditional Insulation**
  - ~ 36 mW/(mK)
- **Vacuum Insulation Panels (VIPs)**
  - ~ 4 mW/(mK) fresh
  - ~ 20 mW/(mK) perforated
- **Gas-Filled Panels (GFPs)**
  - ~ 40 mW/(mK)
- **Aerogels**
  - ~ 15 mW/(mK) (monolithic)
- ***New materials and solutions***

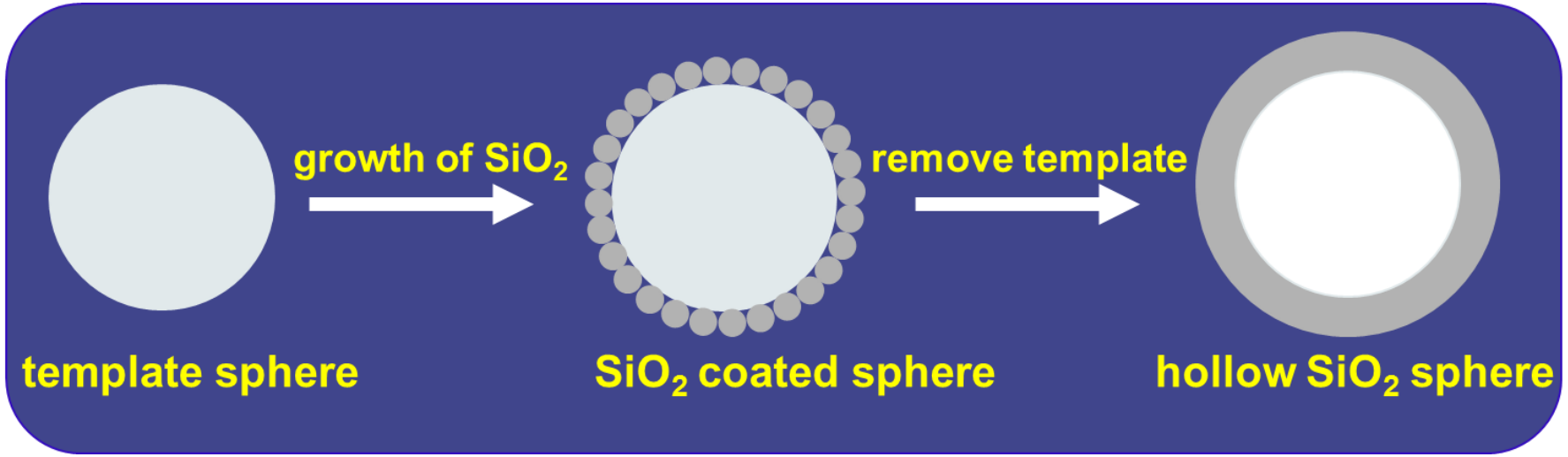


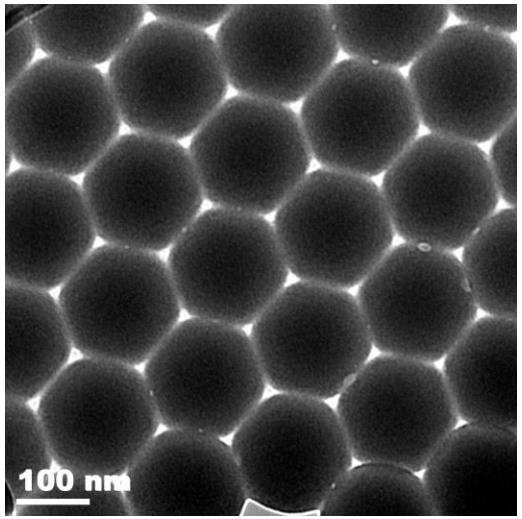
Nano insulation materials





Nano insulation materials - *synthesis*

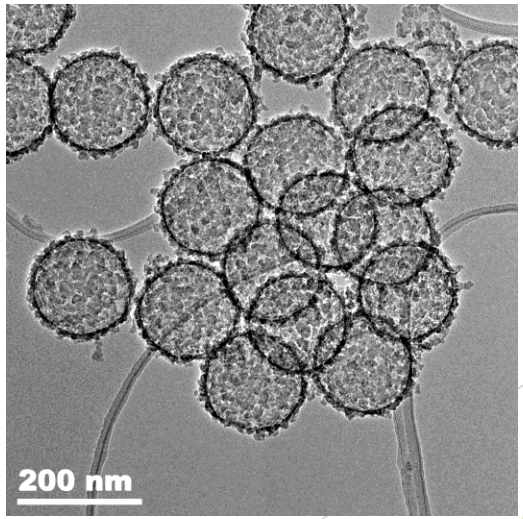




Polystyrene nanoparticles

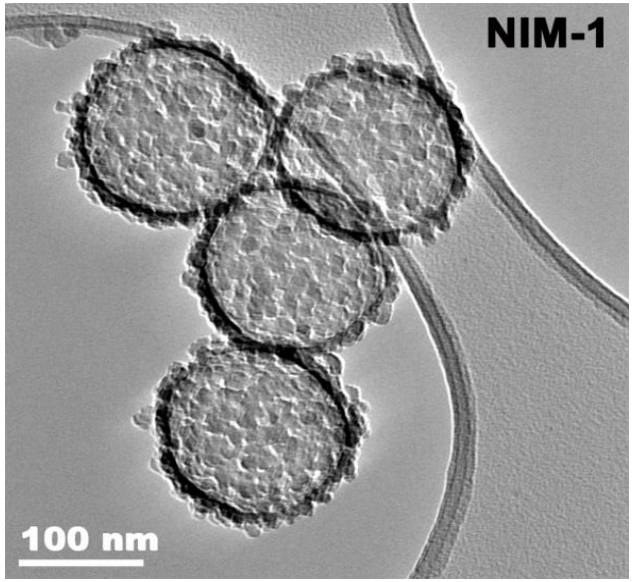
coated with SiO_2

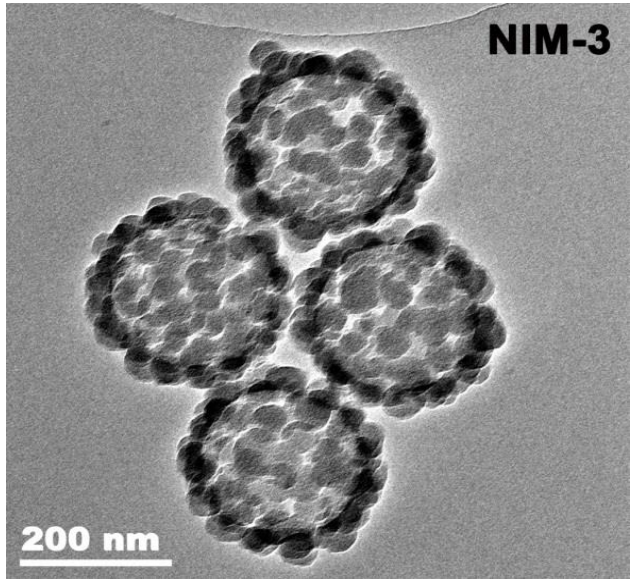
remove PS cores



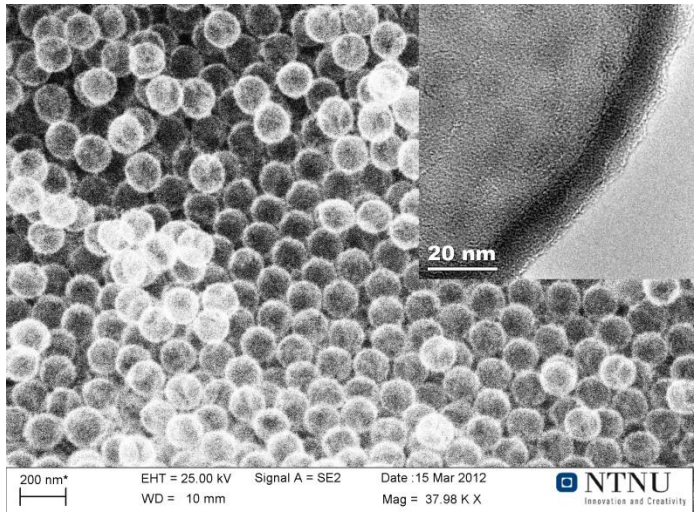
Hollow SiO_2 nanospheres

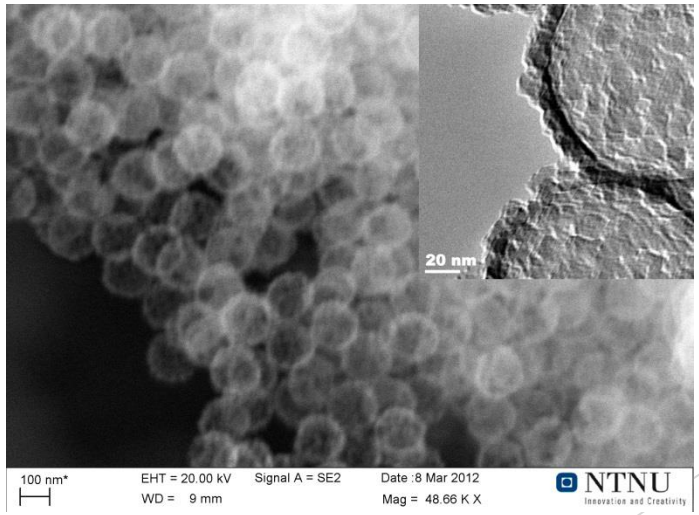
Nano insulation materials - *synthesis*





Dimension





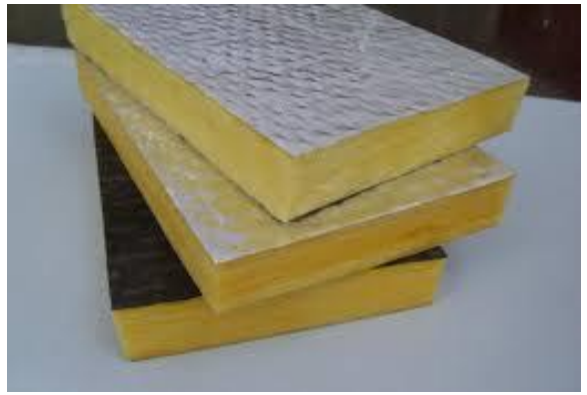
Surface

Nano insulation materials - *property*

	Outer diameter (nm)	Layer thickness (nm)	Thermal conductivity (W/mK)
Solid SiO_2	~ 300	-	0.089
Hollow SiO_2-Etching	~ 300	~ 50	0.067
Hollow SiO_2-PAA	~ 50 – 300	~ 10	0.045
Hollow SiO_2-PS	~ 150	~ 15	0.020
Aerogel	-	-	0.015

Nano insulation materials - *improvement*

HSNS powder



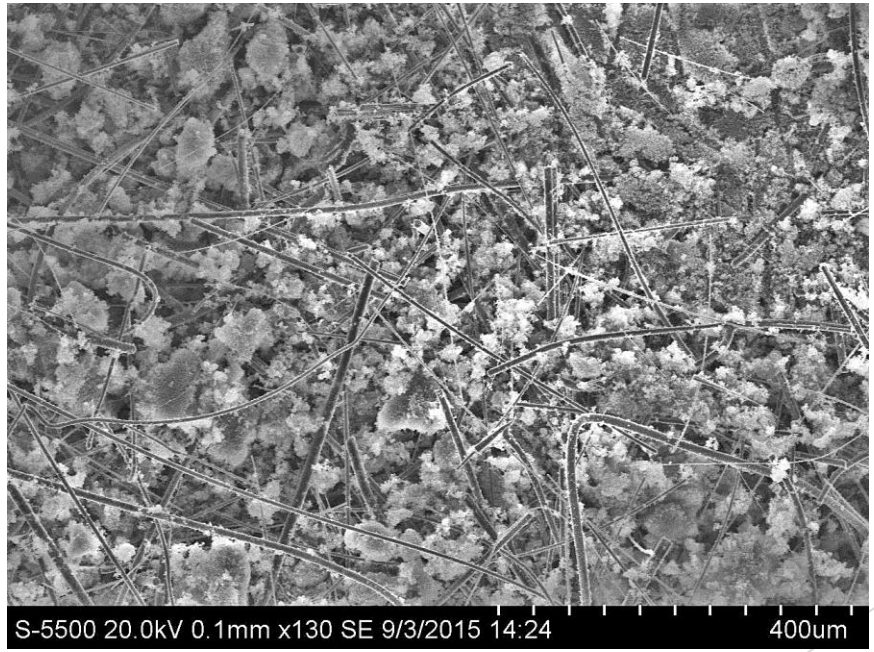
Glass wool

Fiber reinforced

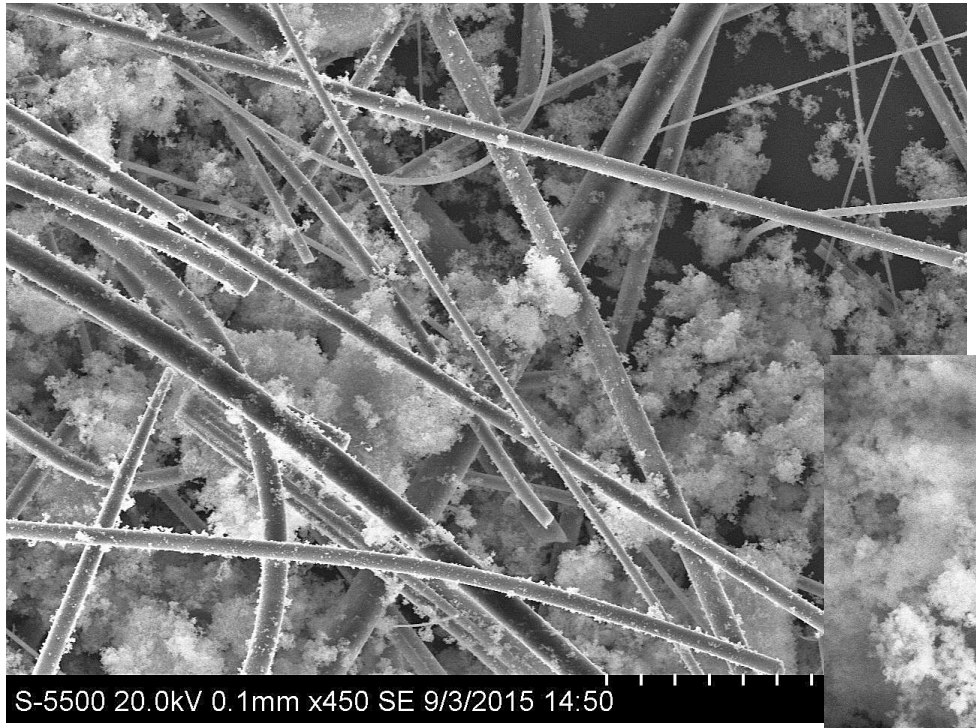
HSNS NIM

Fiber reinforced HSNS NIM

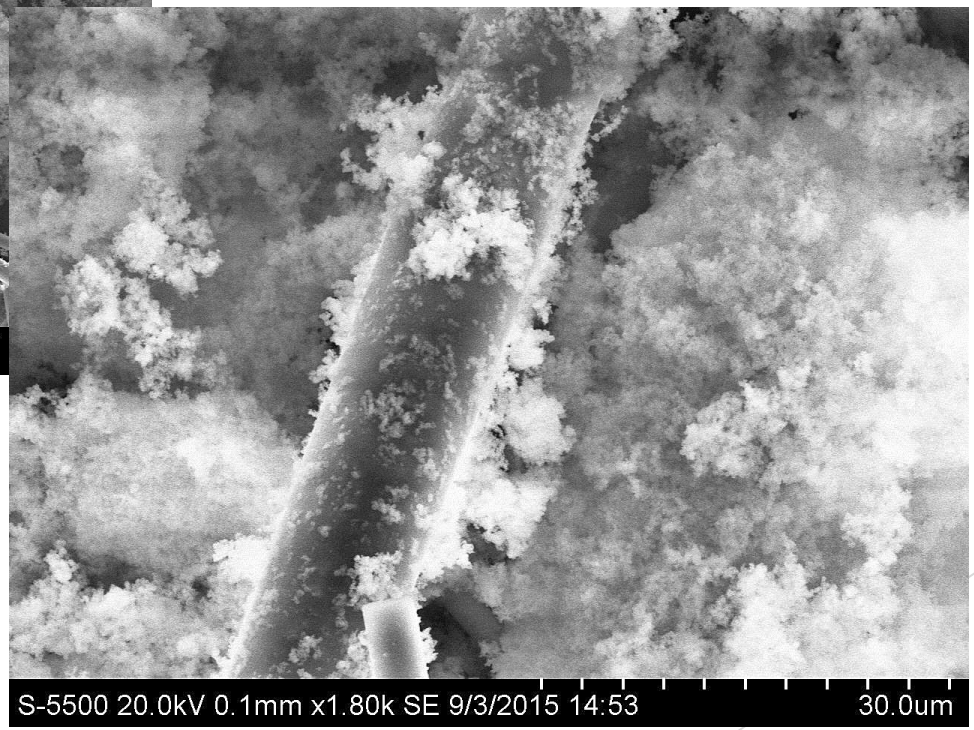
	effective conductivity (mW/(mK))
glass fibers	68
PS/SiO2-glass fibers	73
HSNSs-glass fibers (20 wt.%)	55
HSNSs	~ 37



Fiber reinforced HSNS NIM



Control of the fiber content, surface, diameter



Control of the HSNSs

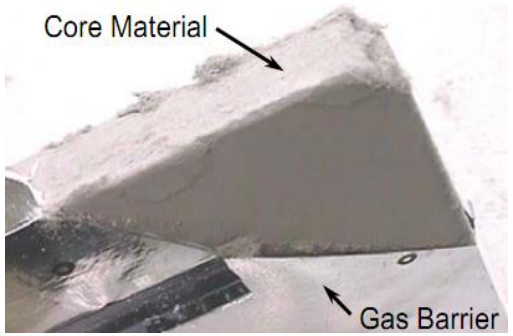
Fiber reinforced HSNS NIM

1. Thermal insulation product

2. Core materials for vacuum insulation panels

Fumed silica (*expensive*)

Glass fibers (*high thermal conductivity*



Conclusions

1. The HSNS NIM represents an interesting material system for thermal insulation applications.
2. Adding glass fiber reinforcement improves the workability of HSNS NIMs, also increases the thermal conductivity.
3. The performance of glass fiber reinforced HSNS NIMs needs to be further enhanced, e.g., by modifying the synthetic parameters.

Thank you!