Production of ZrO_2 nanocomposite films as a minimal surface

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Nanoparticle synthesis by hydrothermal reaction

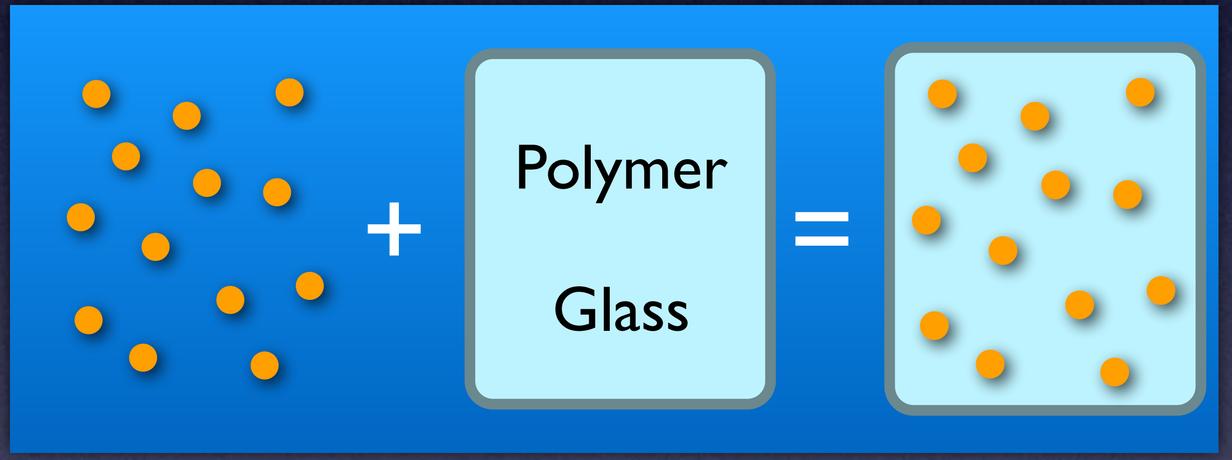
M^{n+} → $M(OH)_n$ → $MO_{n/2}$

ex. $Ti(SO_4)_2$, $Zn(NO_3)_2$ ex. TiO_2, ZnO

200~400°C, ~30 MPa

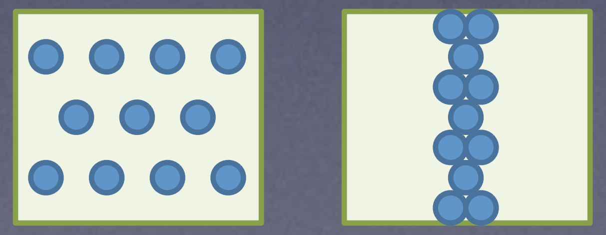
Nanocomposite films

Nanomaterials Matrix Nanocomposite

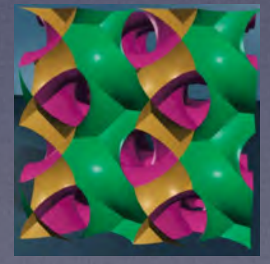


Challenges in nanocomposite materials

- Control in the distribution of nanoparticles
- Designed structure of nanocomposite films



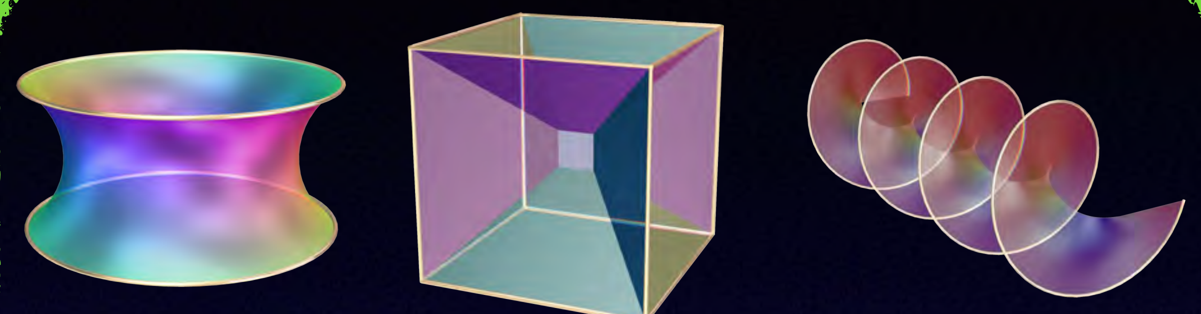
High refractive index High thermal conductivity



S.T. Hyde and G.E. Schröder, *Curr. Opin. Colloid Interface Sci* **8**, 5 (2003)

High surface area
Catalysts

Nano- and micro- structures using minimal surface



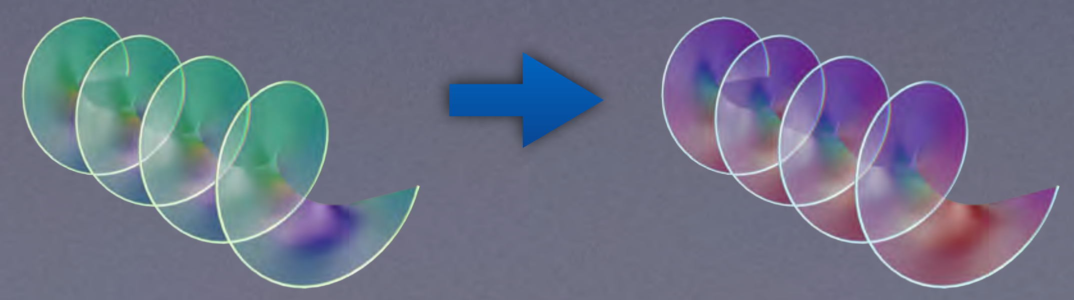
- Frame is the boundary condition
- Size does not matter

We might realize μm and mm minimal surfaces by producing small frame.

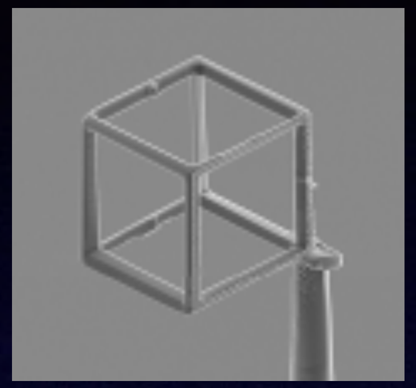
Strategy to prepare minimal surface material

Design of frame by mathematics → Fabrication of frame

Minimal surface with dispersion liquid ← Polymer film with nanopartilces

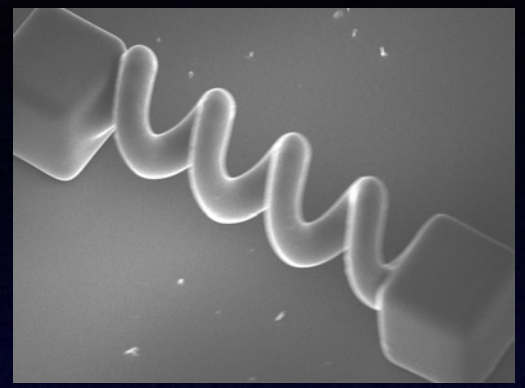


Fabrication of frames at different scales



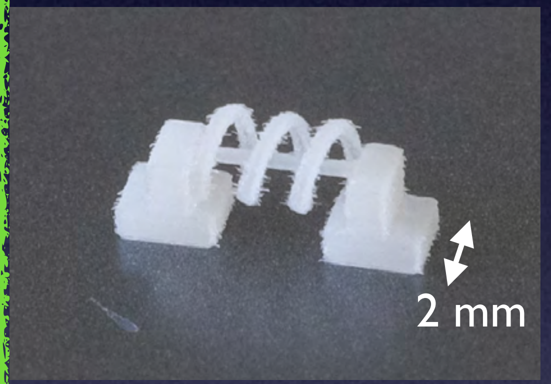
10 μm

Si frame by FIB

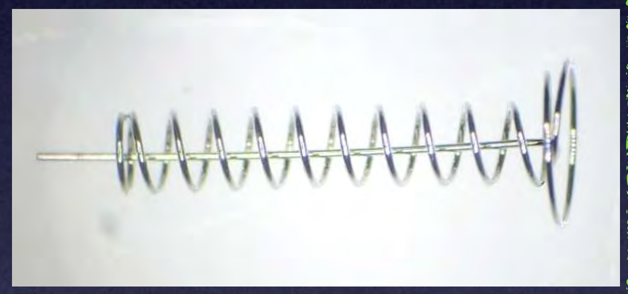


20 μm

Polymer frame by 3D laser lithography system

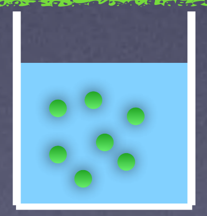


3D ink-jet printer



Coil prepared by machining

Spanning polymer film with nanoparticles



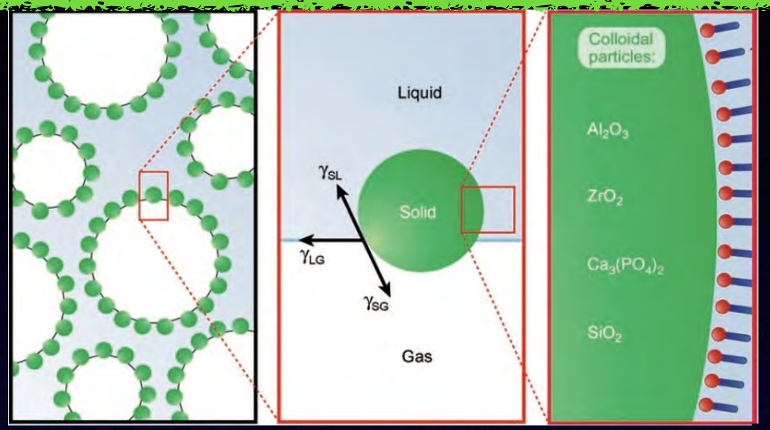
ZrO_2 NPs	15 wt%
PVP	5 wt%
H_2O	80 wt%

Spanning a film
Evaporation of water

Micrometer-sized helicoid nanocomposite film was formed.

ZrO_2 75 vol%

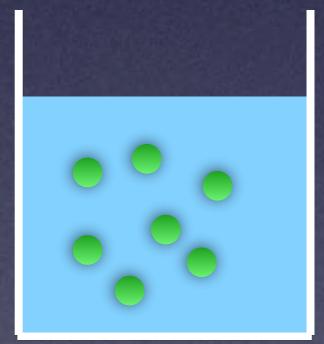
Use of nanoparticles as surfactants



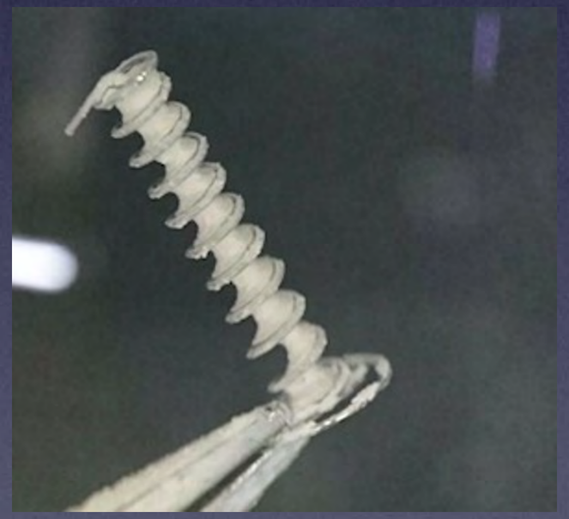
U.T. Gonzenbach *et al.*, *Angew. Chem. Int. Ed.* 45, 21 (2006).
S. Liamas *et al.*, *Colloids Surf. A* 575, 299 (2019).

In this study, ZrO_2 nanoparticles were also used as surfactants

Results:



ZrO_2 NPs, CTAB, H_2O



ZrO_2 93.4 wt%

ZrO_2 nanoparticles formed minimal surface at ~mm scale.

Other oxide nanoparticles are studied to prepare minimal surface nanocomposite films.