

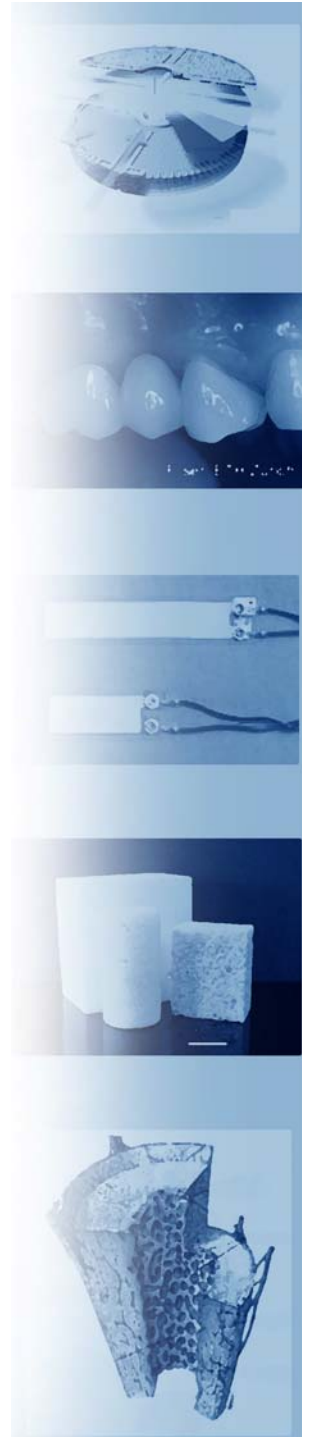
ETH Zurich, September 5th 2008

Controlled assembly of supracolloidal structures using microfluidics

André R. Studart

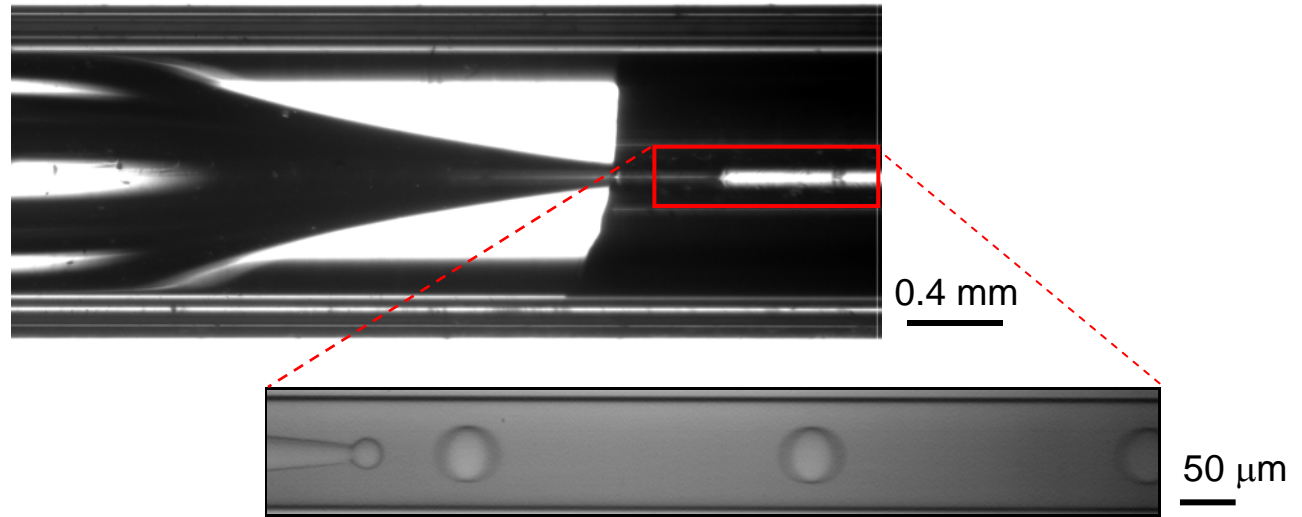


Harvard University
School of Engineering and Applied Sciences



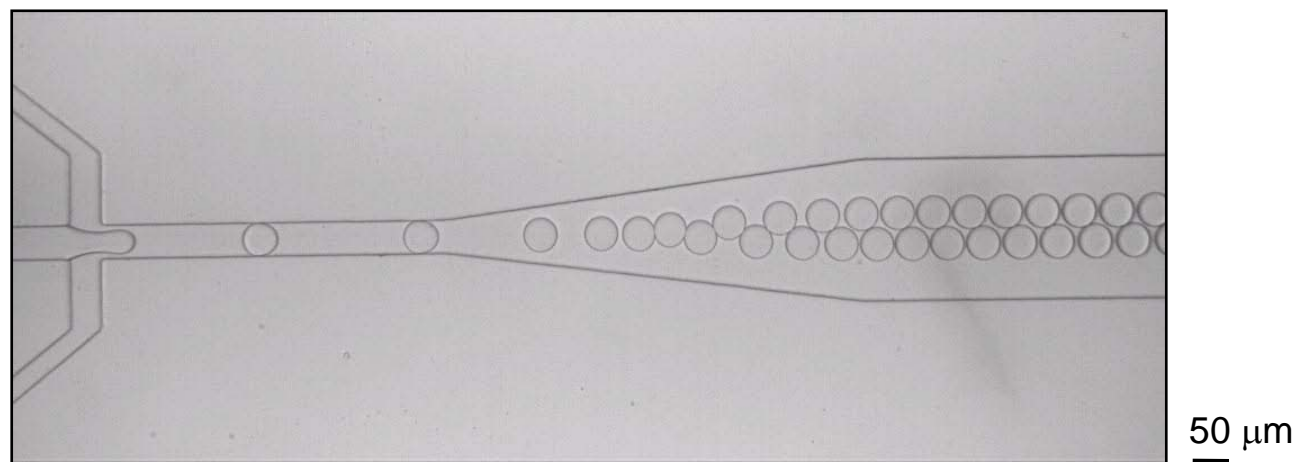
Microfluidics: one droplet at a time

Glass
microcapillary
device



A.R. Studart, H.C. Shum, D.A. Weitz, *J. Phys. Chem. B*, **accepted** (2008).

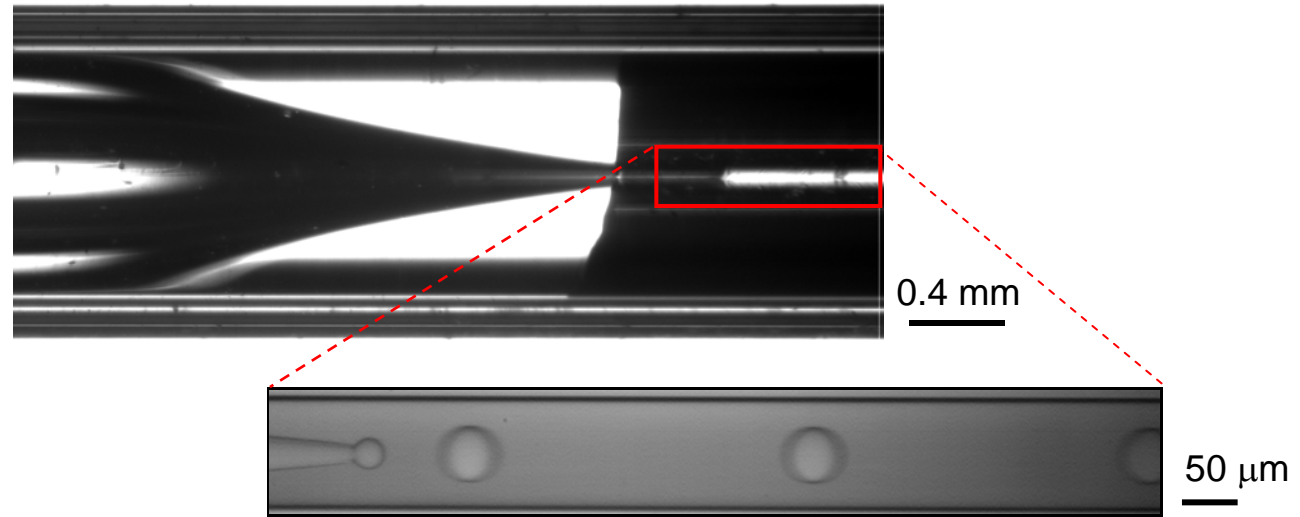
PDMS
device



Courtesy: F.E. Angeli

Microfluidics: one droplet at a time

Glass
microcapillary
device

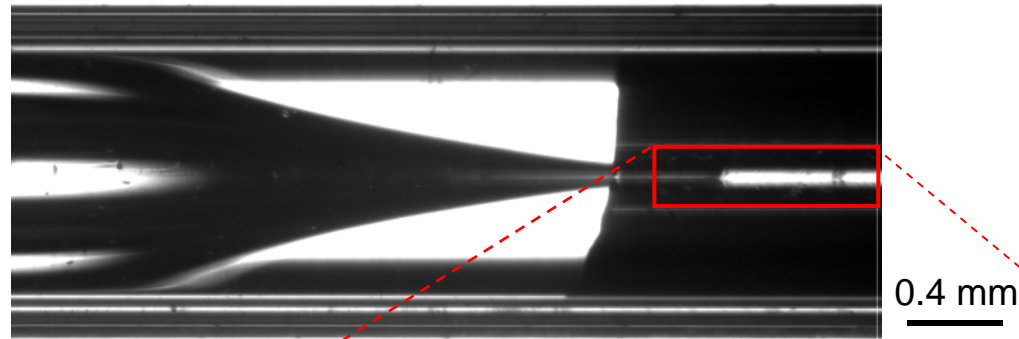


A.R. Studart, H.C. Shum, D.A. Weitz, *J. Phys. Chem. B*, **accepted** (2008).

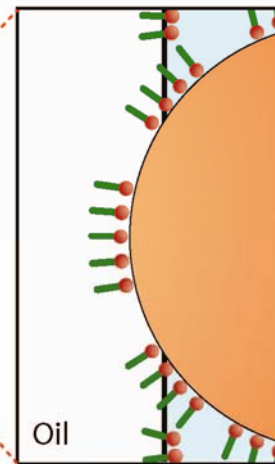
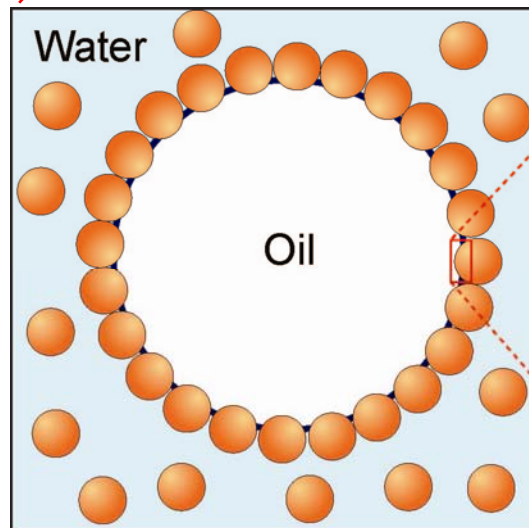
*Can this technique be used to form
new supracolloidal structures ?*

*Can this approach help us get more insight into the
fabrication of porous materials from foams and emulsions ?*

Particle-stabilized droplets

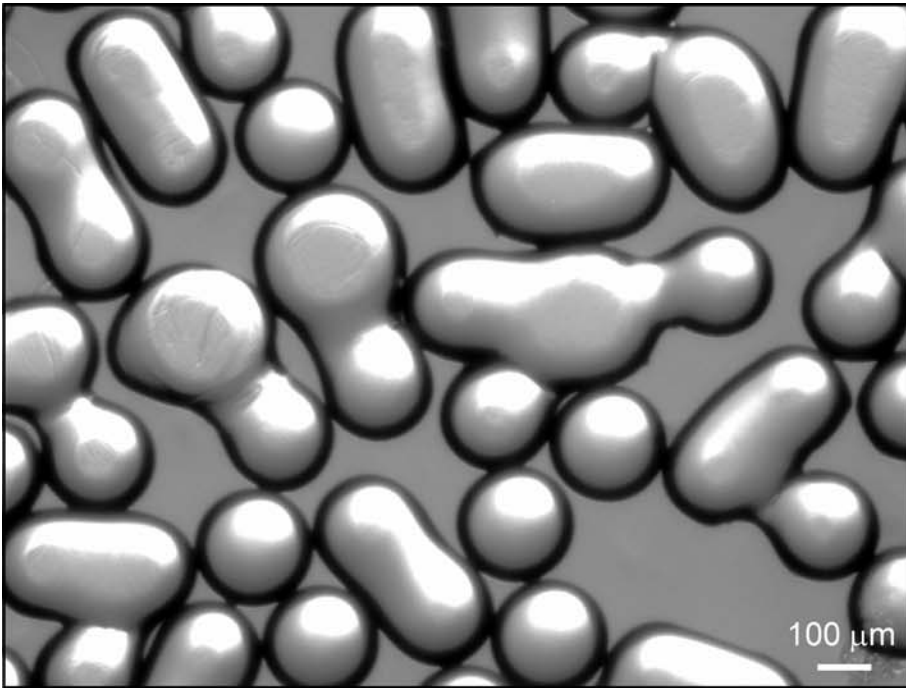


*Particles
on droplet
surface
& continuous
phase*

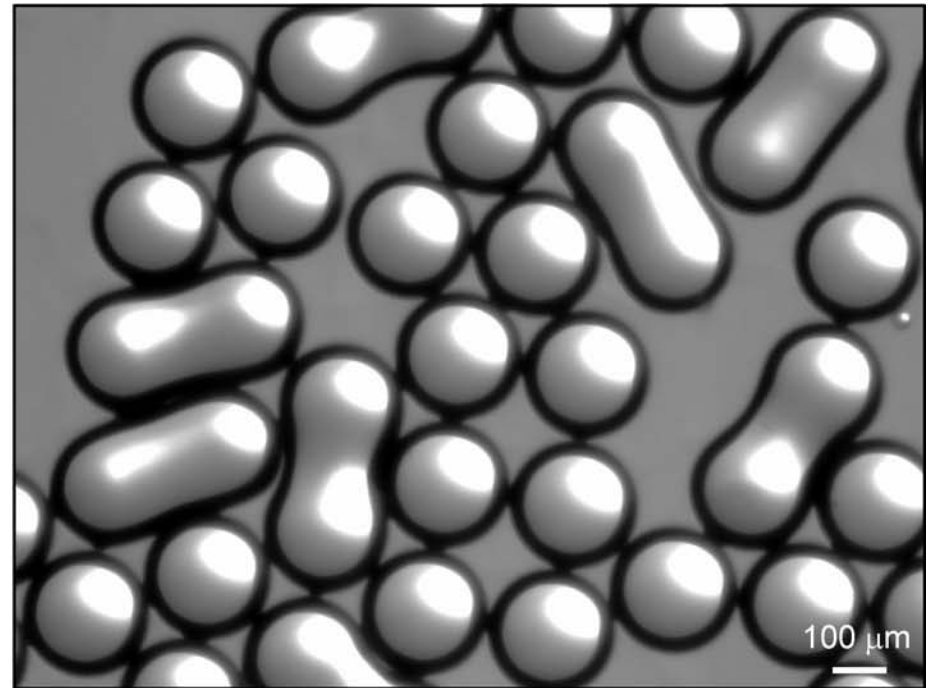


Surfactant: CTAB
Particle: Silica
Oil: Octane

Particle-stabilized droplets



*Outer fluid: 10000 $\mu\text{L/h}$
Inner fluid: 1000 $\mu\text{L/h}$
5 vol% particles*



*Outer fluid: 5000 $\mu\text{L/h}$
Inner fluid: 500 $\mu\text{L/h}$
5 vol% particles*

Droplets undergo arrested coalescence into non-spherical shapes !

A.R. Studart, H.C. Shum, D.A. Weitz, "Arrested coalescence of particle-coated droplets into non-spherical supracolloidal structures", *Journal of Physical Chemistry B*, **accepted** (2008).

Arrested coalescence of droplets

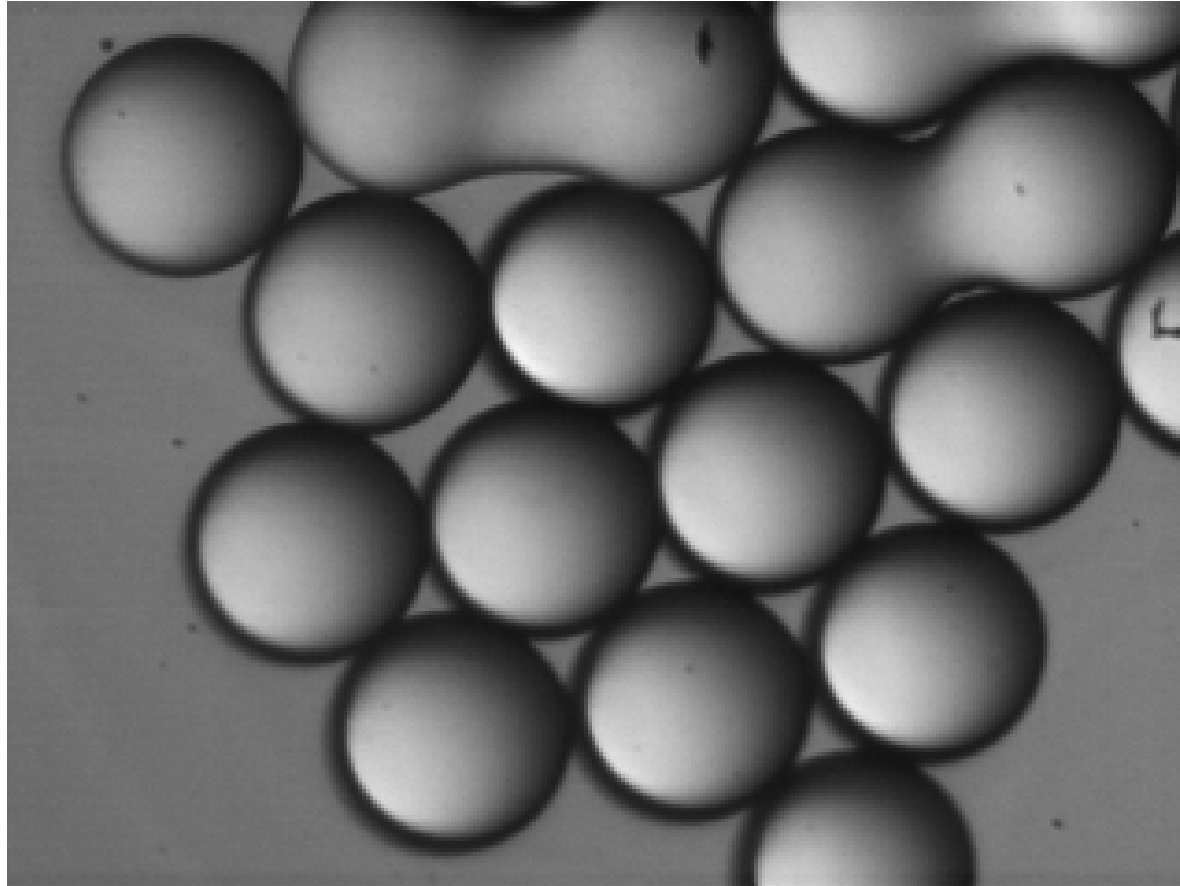


Image acquisition speed: 20,000 frames/s

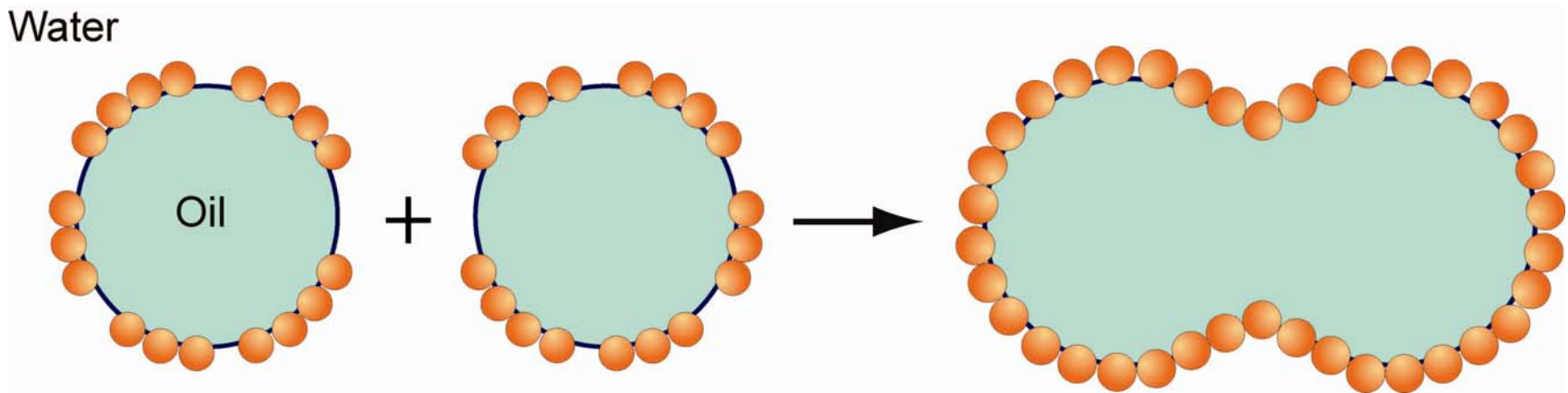
Time scale for coalescence ~ 50 μ s

A.R. Studart, H.C. Shum, D.A. Weitz, "Arrested coalescence of particle-coated droplets into non-spherical supracolloidal structures", *Journal of Physical Chemistry B*, **accepted** (2008).

Arrested coalescence of droplets



Particle jamming at the oil-water interface ?



For initial droplets
of equal size:

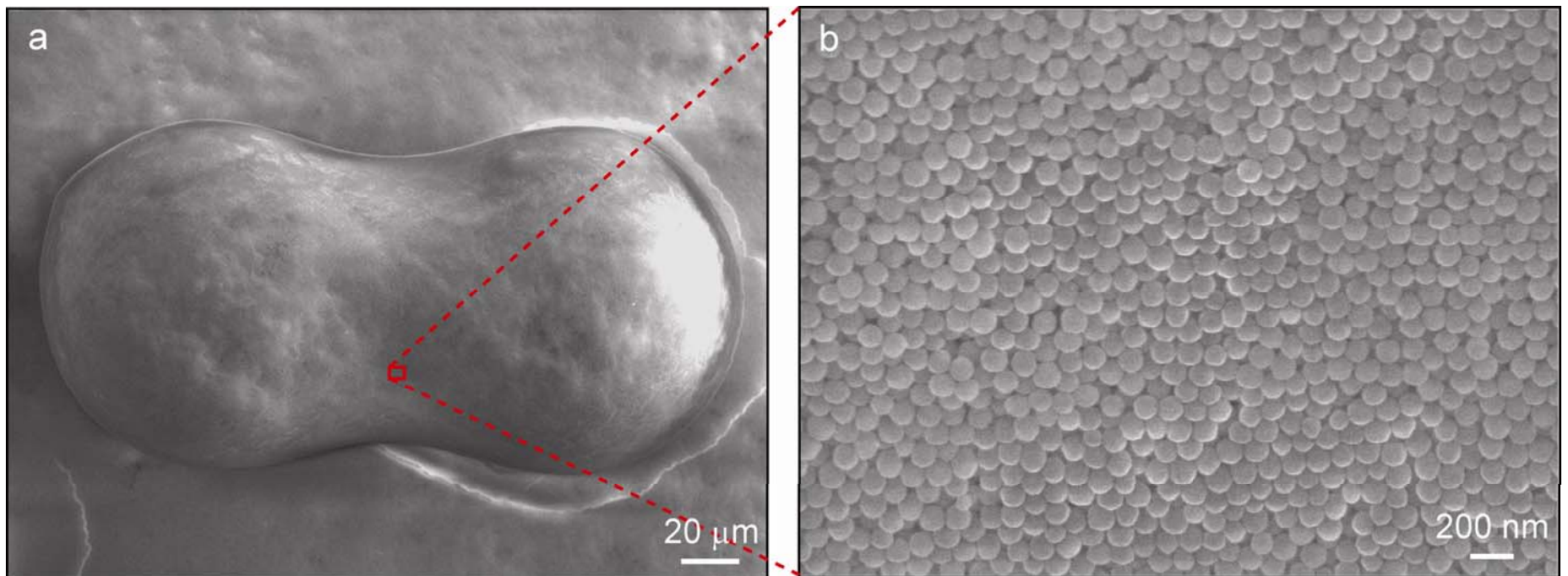
Full
coalescence



Increase of 26%
in surface coverage
by particles

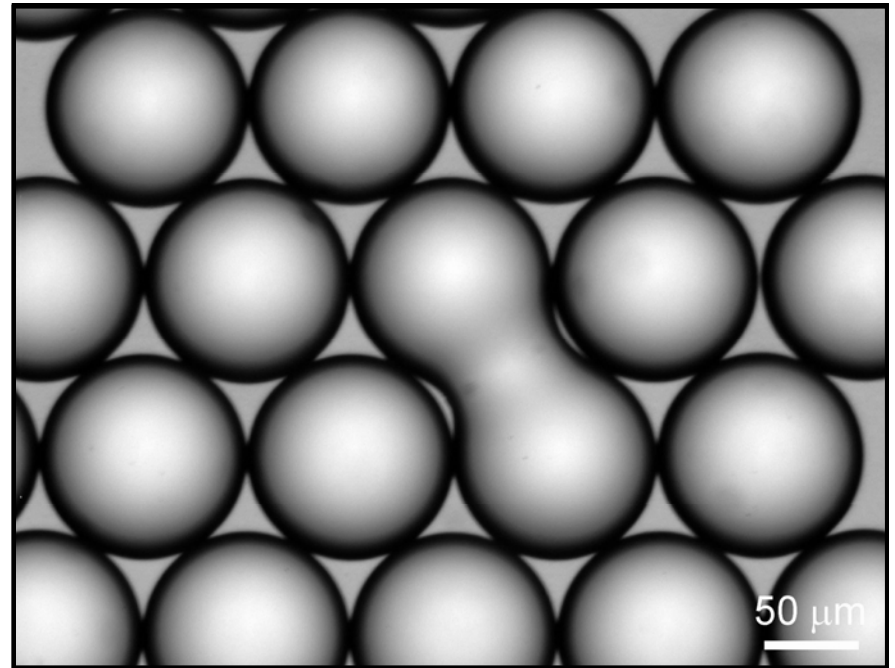
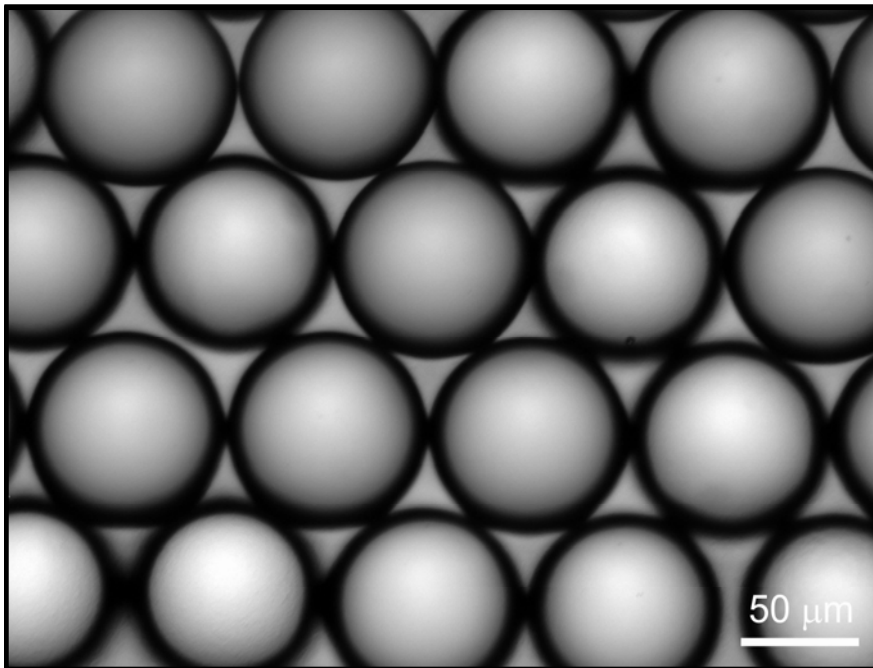
Arrested coalescence of droplets

Particle jamming at interface keeps non-spherical shape



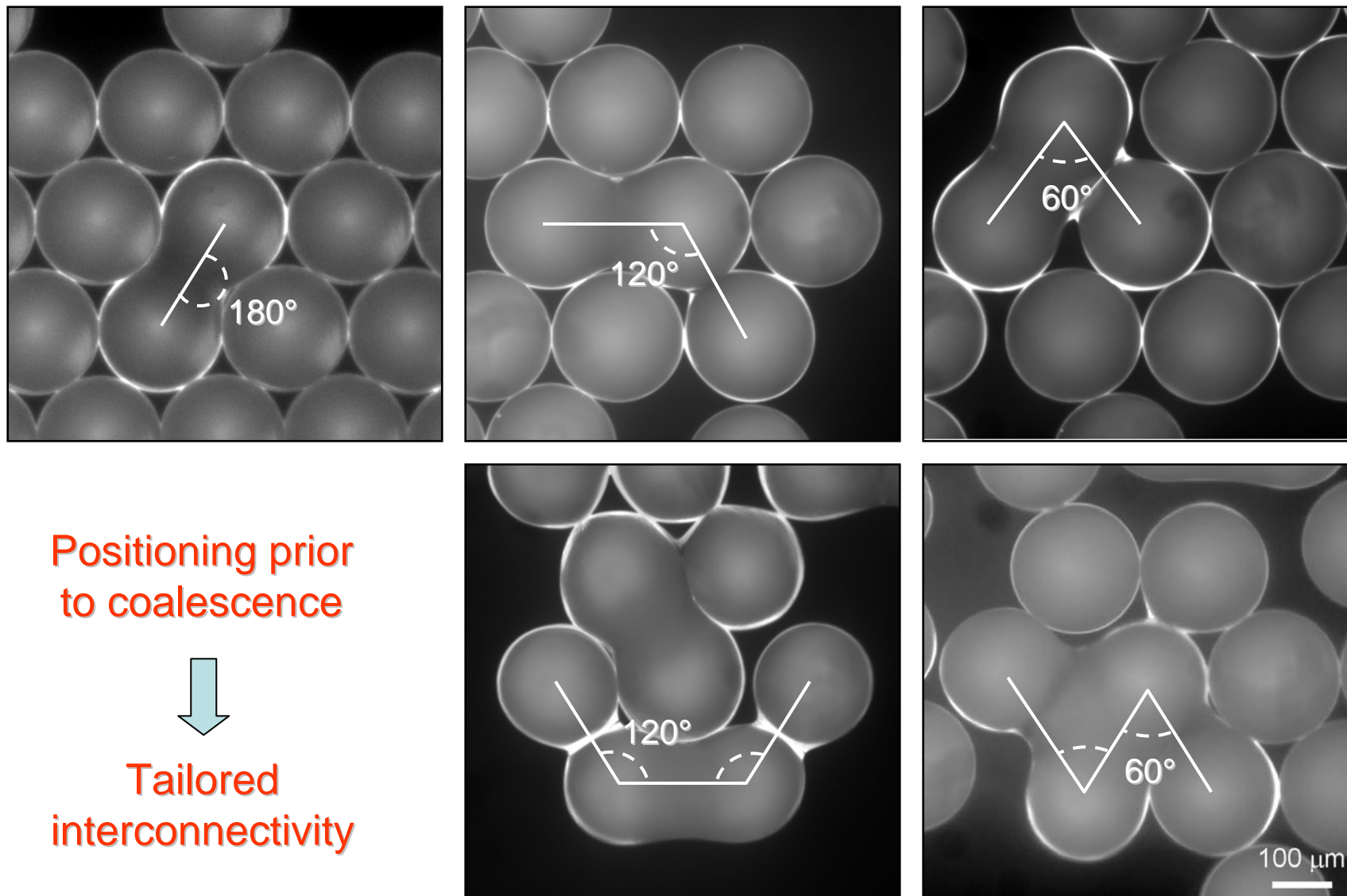
A.R. Studart, H.C. Shum, D.A. Weitz, "Arrested coalescence of particle-coated droplets into non-spherical supracolloidal structures", *Journal of Physical Chemistry B*, **accepted** (2008).

Crystallization before coalescence



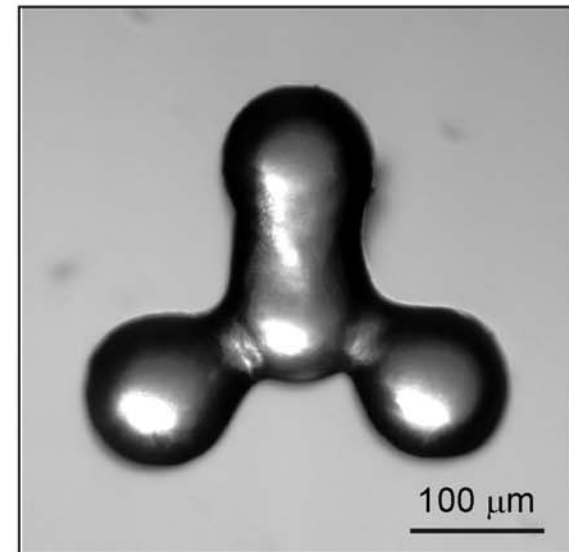
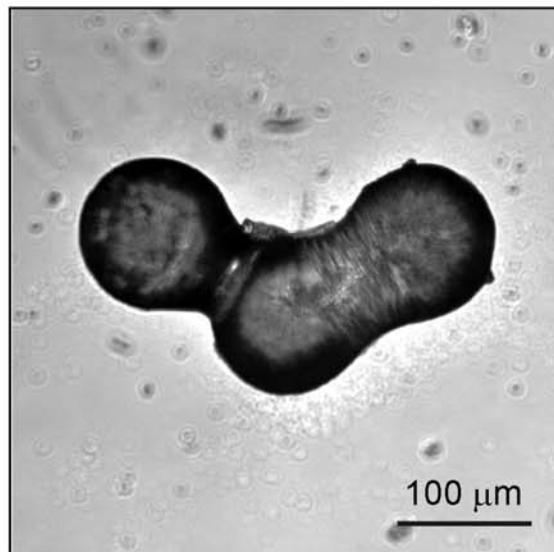
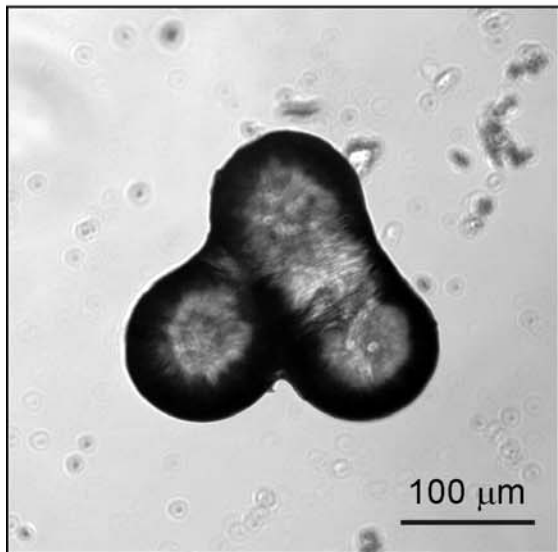
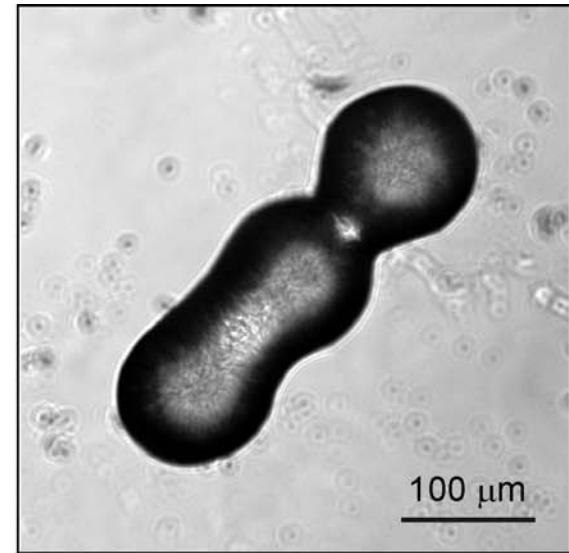
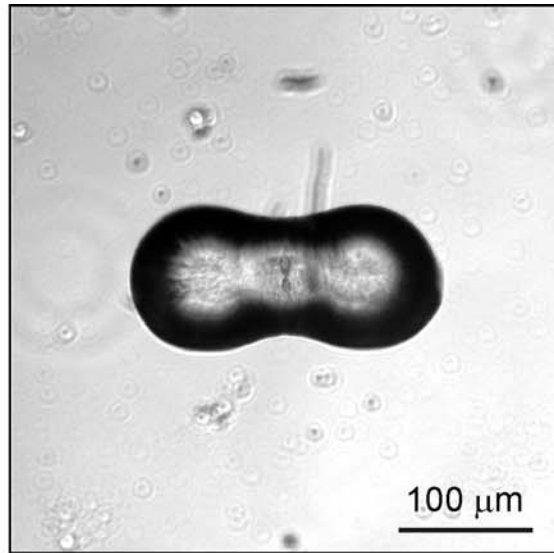
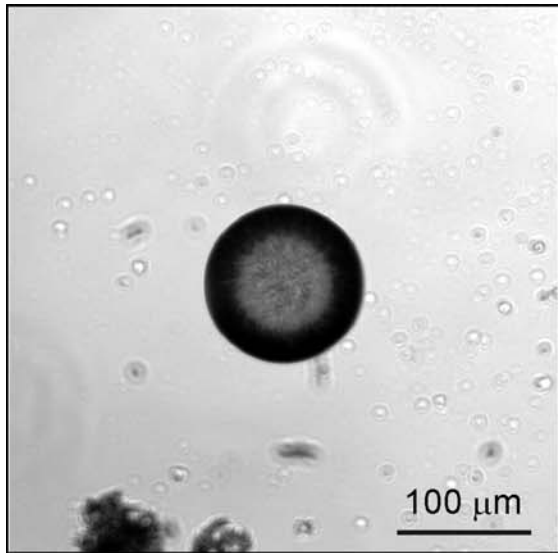
A.R. Studart, H.C. Shum, D.A. Weitz, "Arrested coalescence of particle-coated droplets into non-spherical supracolloidal structures", *Journal of Physical Chemistry B*, **accepted** (2008).

Arrested coalescence under defined geometries



A.R. Studart, H.C. Shum, D.A. Weitz, "Arrested coalescence of particle-coated droplets into non-spherical supracolloidal structures", *Journal of Physical Chemistry B*, **accepted** (2008).

Non-spherical capsules

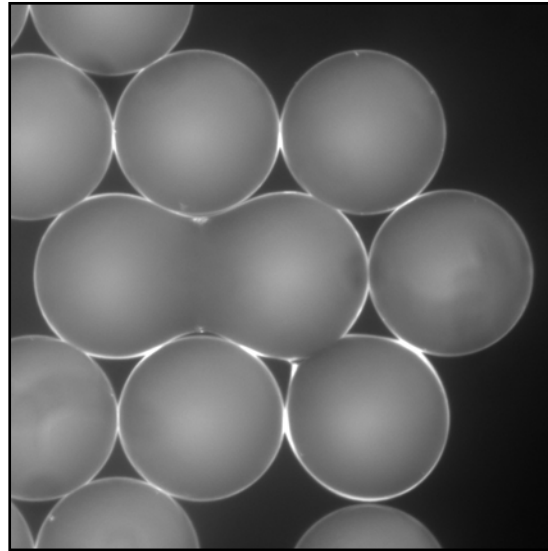


A.R. Studart, H.C. Shum, D.A. Weitz, "Arrested coalescence of particle-coated droplets into non-spherical supracolloidal structures", *Journal of Physical Chemistry B*, **accepted** (2008).

Implications for porous materials

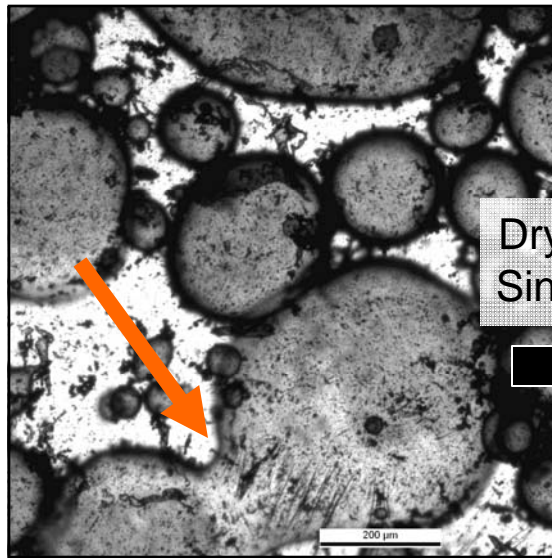


Arrested
coalescence
of droplets

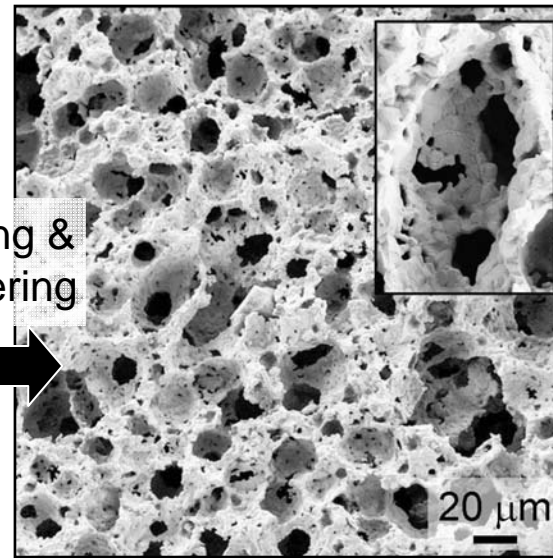


Mechanism for the
formation of
interconnected
pores in
particle-stabilized
emulsions & foams

Water-in-oil
emulsion
stabilized by
iron oxide
particles



Drying &
Sintering



Macroporous
ceramic with
open,
interconnected
pores

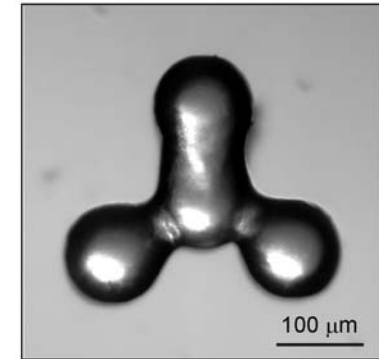
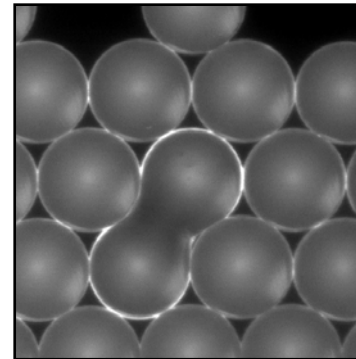
Conclusions



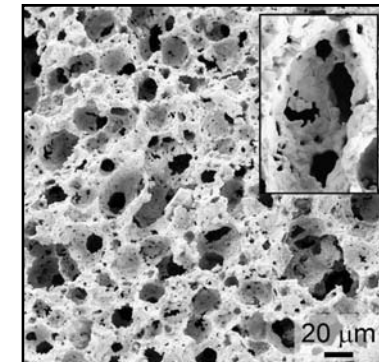
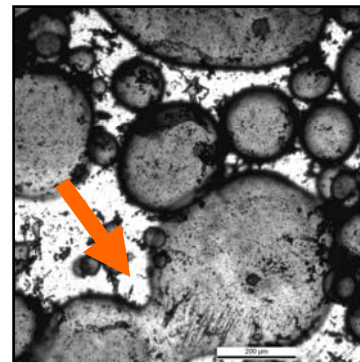
Microfluidics is a powerful tool to:



- produce new supracolloidal structures with non-spherical shape



- provide insights into processes affecting the final structure of macroporous materials



Acknowledgements



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Anderson Shum

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FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

Thank you !

