Morphology of Polymer Materials and their Characterization

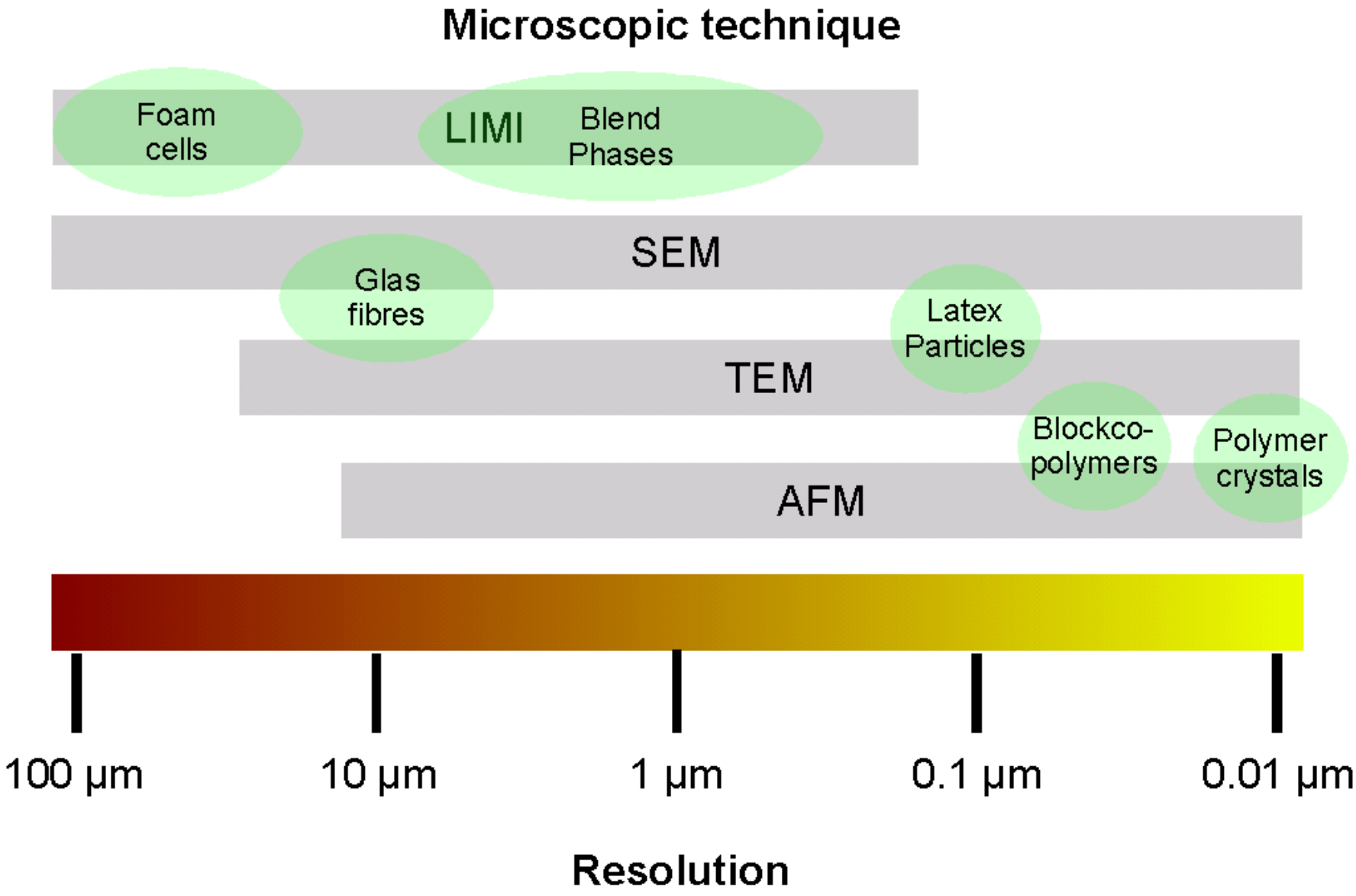
Hans-Georg Braun

Leibniz Institute of Polymers
Max Bergmann Center of Biomaterials

Polymer based materials

Synthetic polymer materials	Biomaterials
Polymer blends	
Fibres	Natural fibres (Silk, Cellulose)
Fibre reinforced materials	Wood, ivory Bone, Mussel shells
Particle filled polymers	
Foams	Diatomes, cork
Hydrogels	Agarose

Microscopic techniques



Optical microscopic techniques

Light Microscopy

Confocal Laser Scanning Microscopy

Conventional Light Microscopy

Electron Microscopy

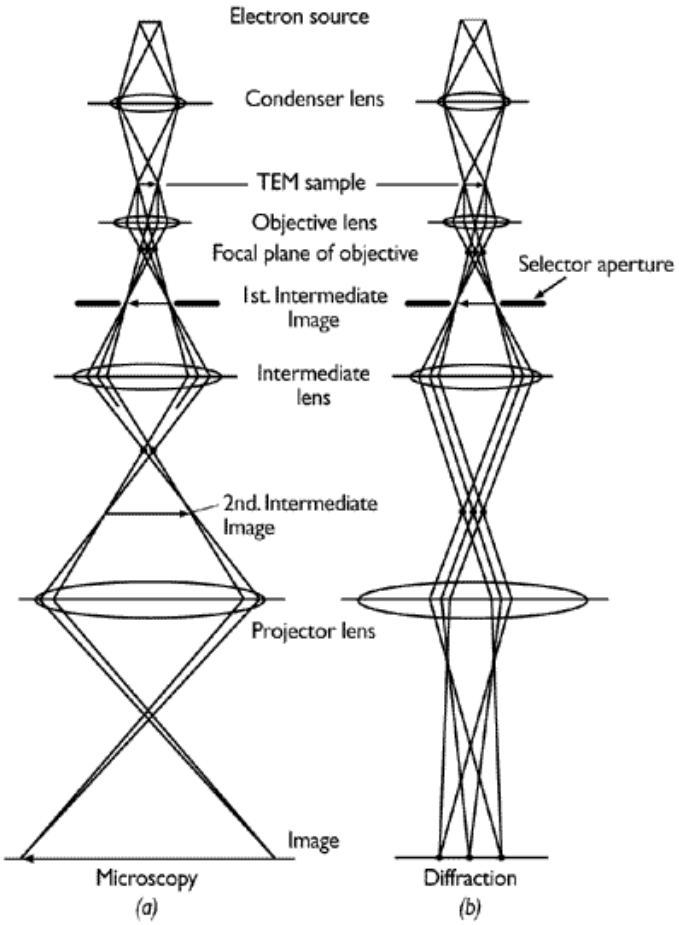
Scanning Electron Microscopy

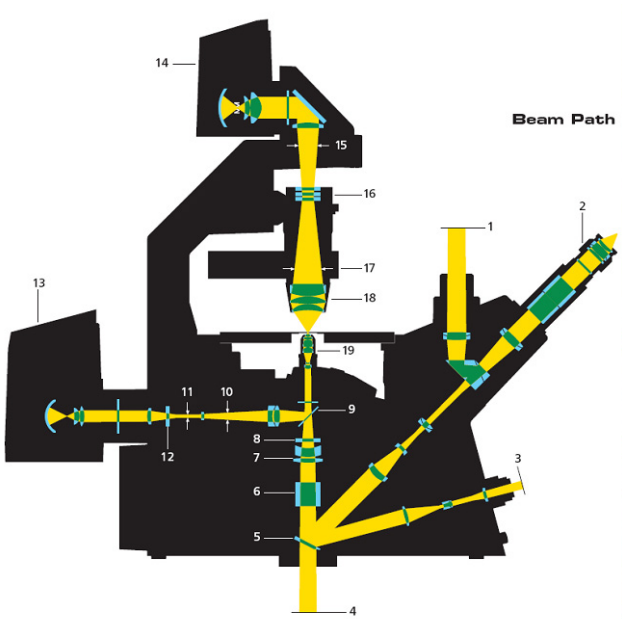
Transmission Electron Microscopy

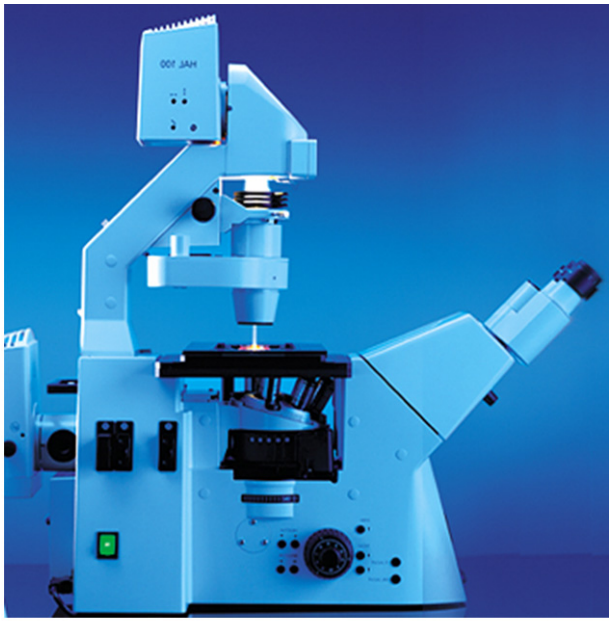
Similar optical principles but different

b) Resolution
c) Contrast mechanisms
d) Technical Realisation

Optical beam path and basic optical elements





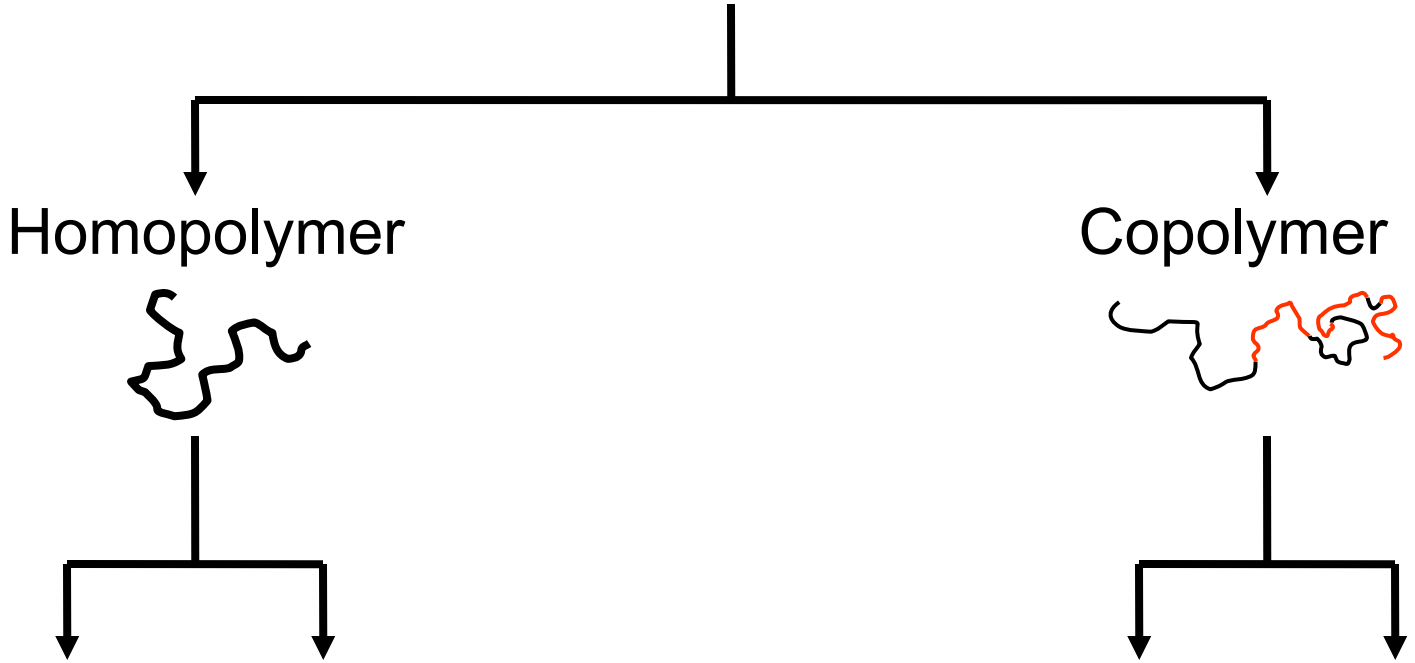


1 intermediate image plane phototube
2 eyepiece
3 intermediate image plane frontport
4 intermediate image plane baseport
5 beam path switching between baseport/ frontport/vis
6 sideport prisms
7 tube lens
8 analyzer
9 reflector module
10 luminous field diaphragm
11 aperture diaphragm
12 filter slider
13 HBO lamp
14 HAL lamp
15 luminous field diaphragm
16 polarizer
17 aperture diaphragm
18 condenser
19 objective

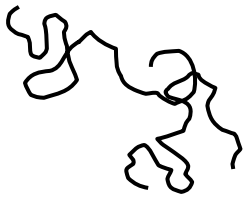
Winfried Wiegraebe, Stowers Institute for Medical Research

TEM **Light microscope**

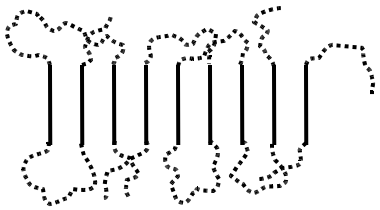
Polymer morphology



amorphous



crystalline



blockcopolymer

statistical

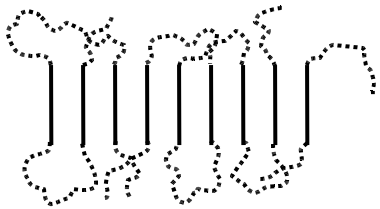
Polymer morphology

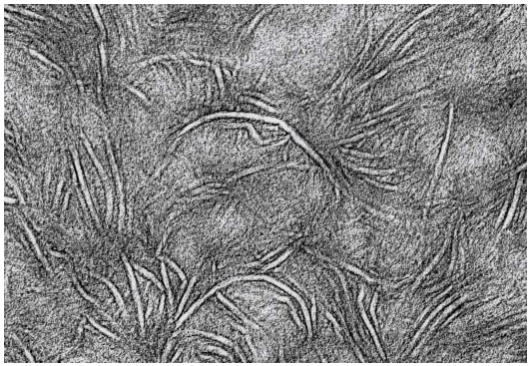
Homopolymer

Copolymer

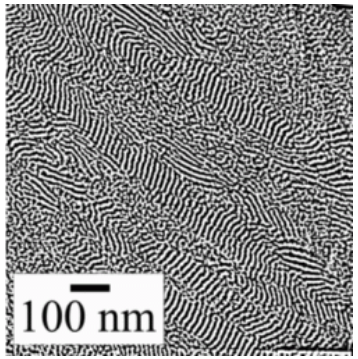
crystalline

blockcopolymer

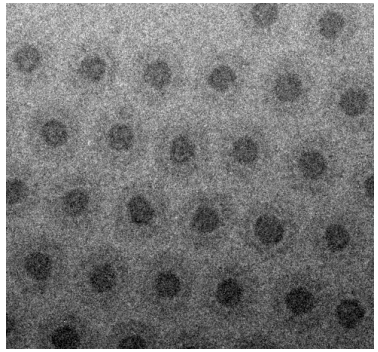




Solid state

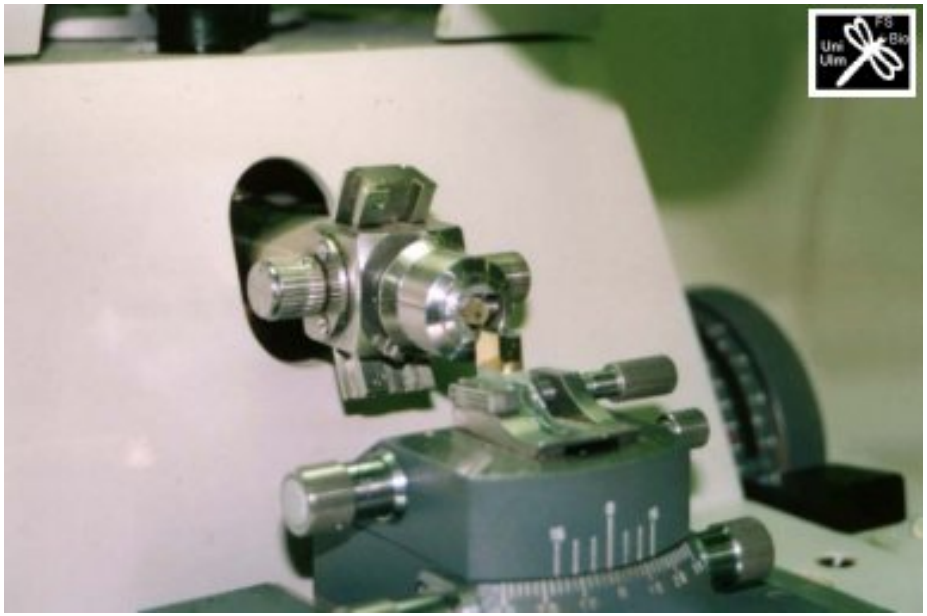


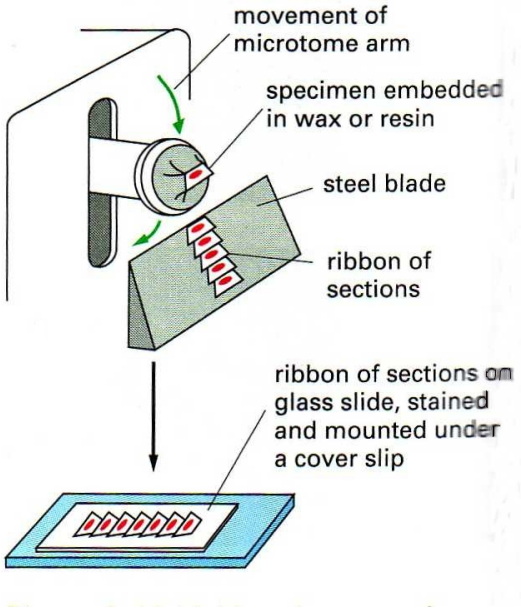
Solid state



Aqueous

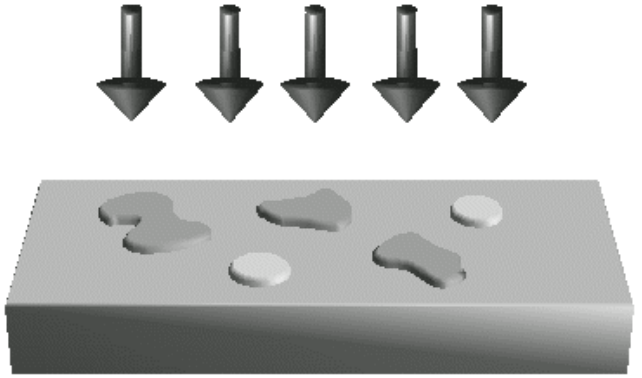
Microtome sectioning



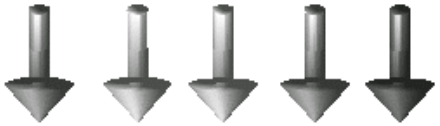


Microscopic techniques

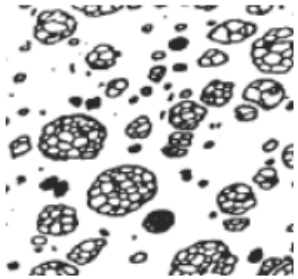
Electron microscopy

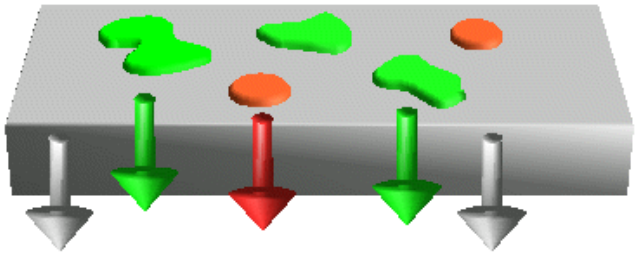


Low electron density difference



Contrast enhancement through selective staining





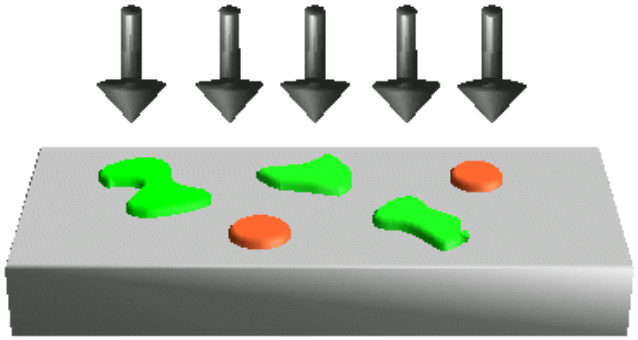
High electron density difference

Microscopic techniques

Microscopic technique

Light microscopy

Electron microscopy



Refractive Index

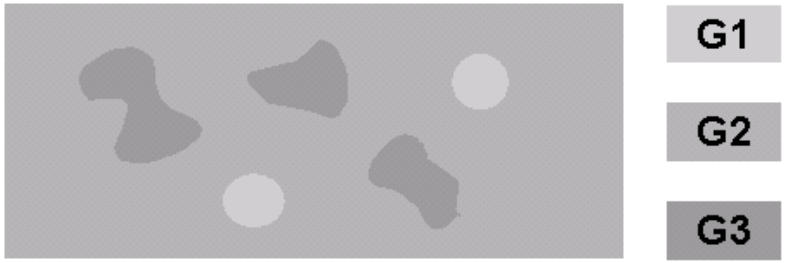
Polarizibility

Contrast mechanism

Electron density

Atomic number

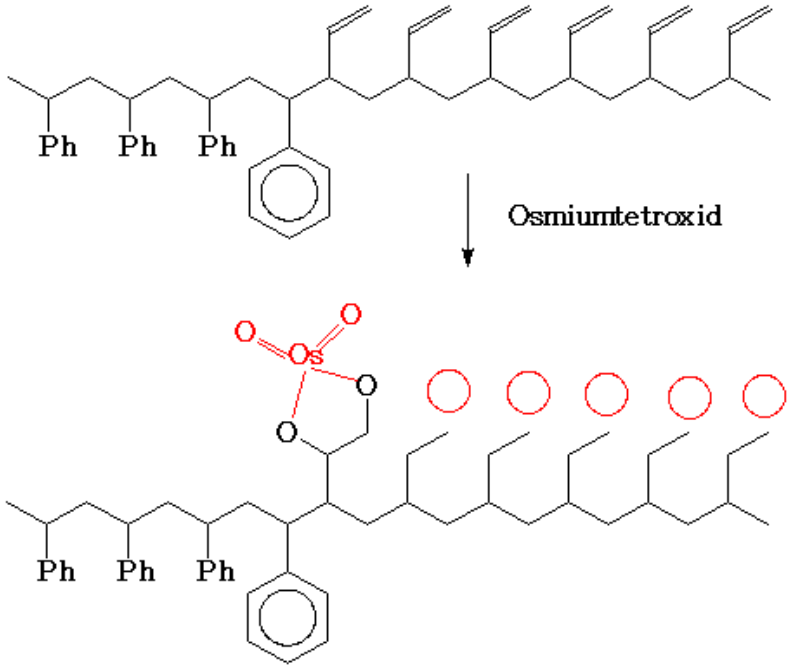
Polymers: C,O,H,N

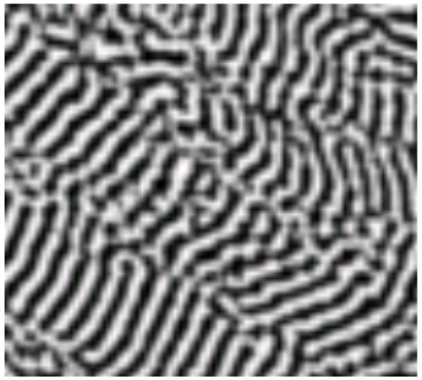


$C = (G1 - G2) / G1 + G2$

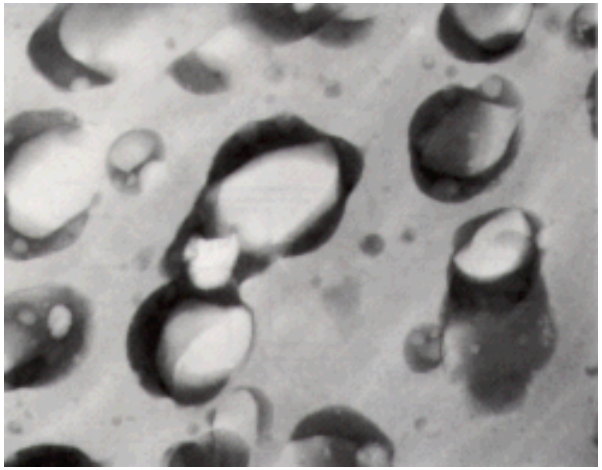
Microscopic techniques

Staining

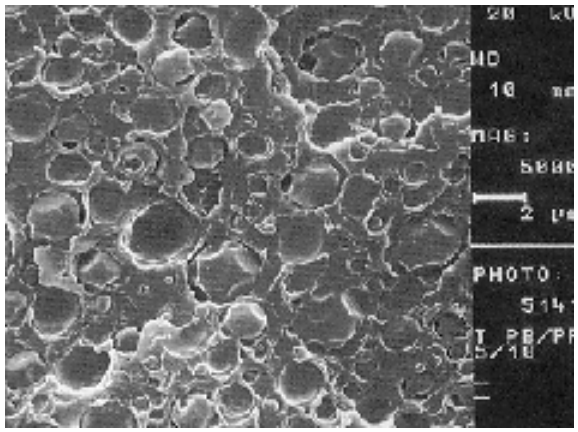




Typical Blend morphology

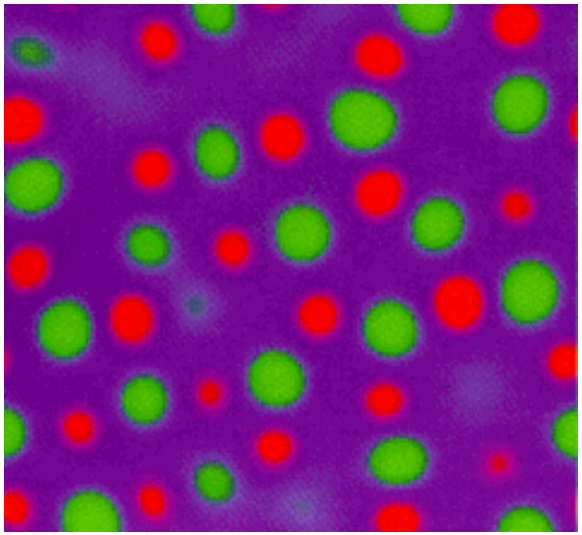


Dispersed phase
TEM

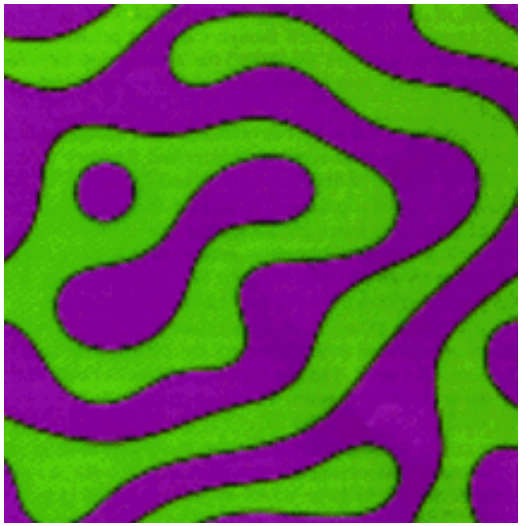


Bicontineous phase
Fracture surface SEM

Typical Blend morphology



Dispersed phase



Bicontinuous phase

Particle morphologies

High Impact Polystyrene – HIPS – TEM stained

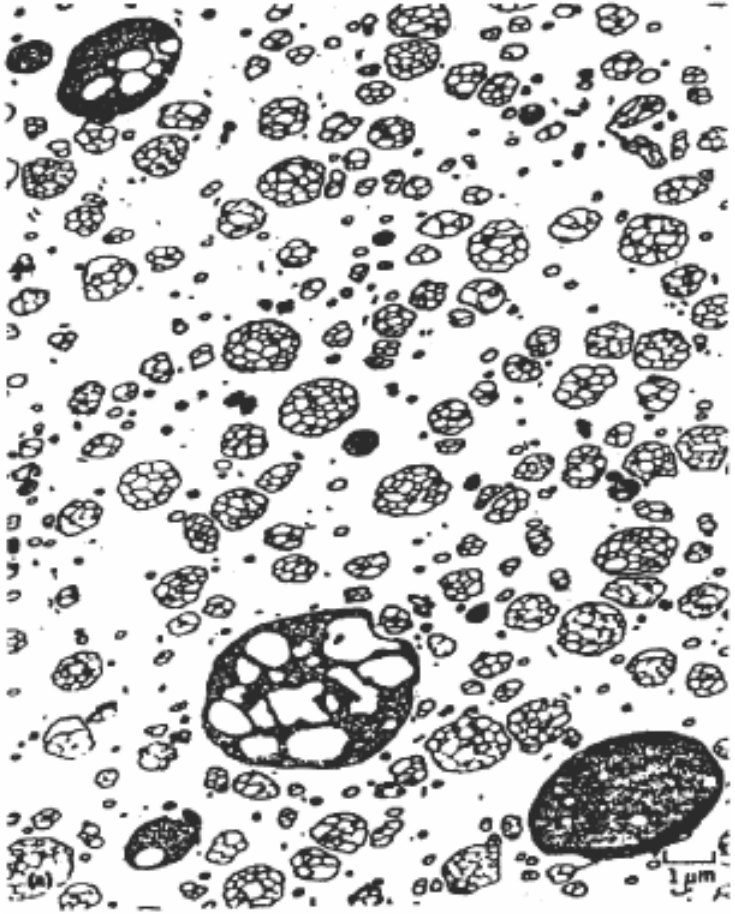
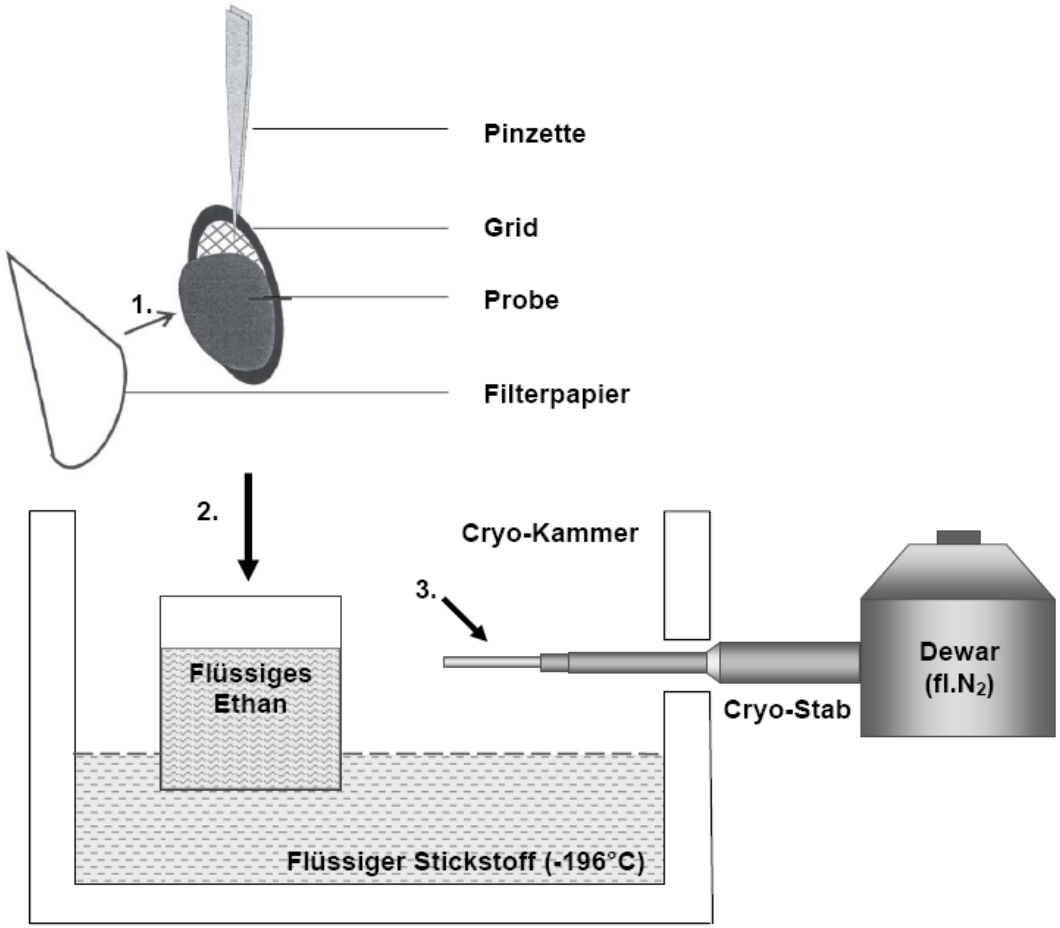


Figura 4. Imagem MET de HIPS produzido por polimerização em massa ou solução. Morfologia tipo *salami*[3] A parte escura (fase dispersa) identifica a borracha e a parte clara (fase contínua e inclusões) o poliestireno.

Cryo Electron Microscopy

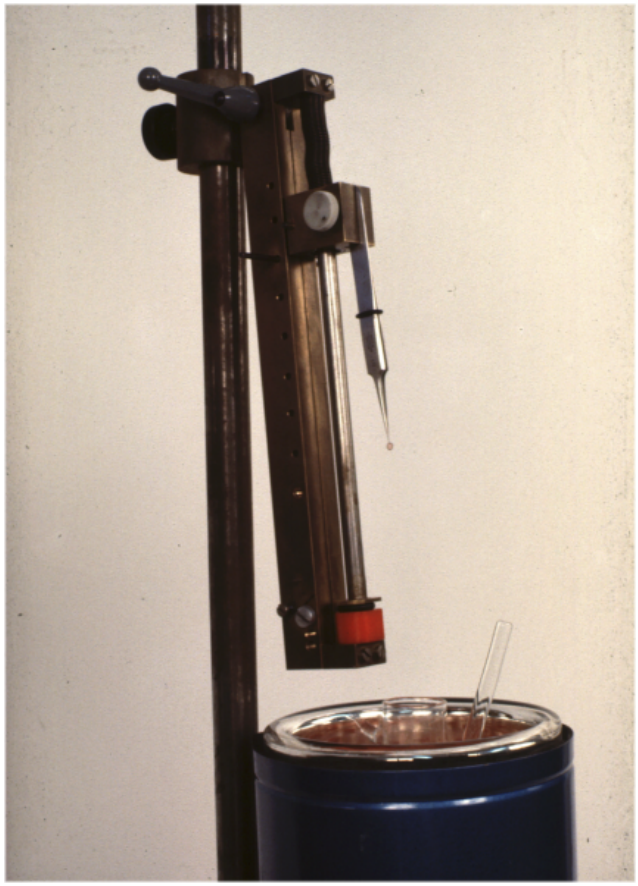
Frozen hydrated specimen preparation



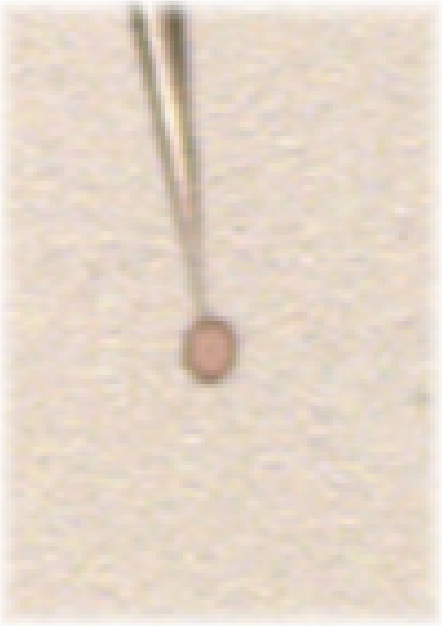
Anja Rank
Diss. Uni. Freiburg
Herstellung und Charakterisierung von Vesikeln aus amphiphilen Blockcopolymeren

Cryo Electron Microscopy

Rapid freezing with a simple freeze punger

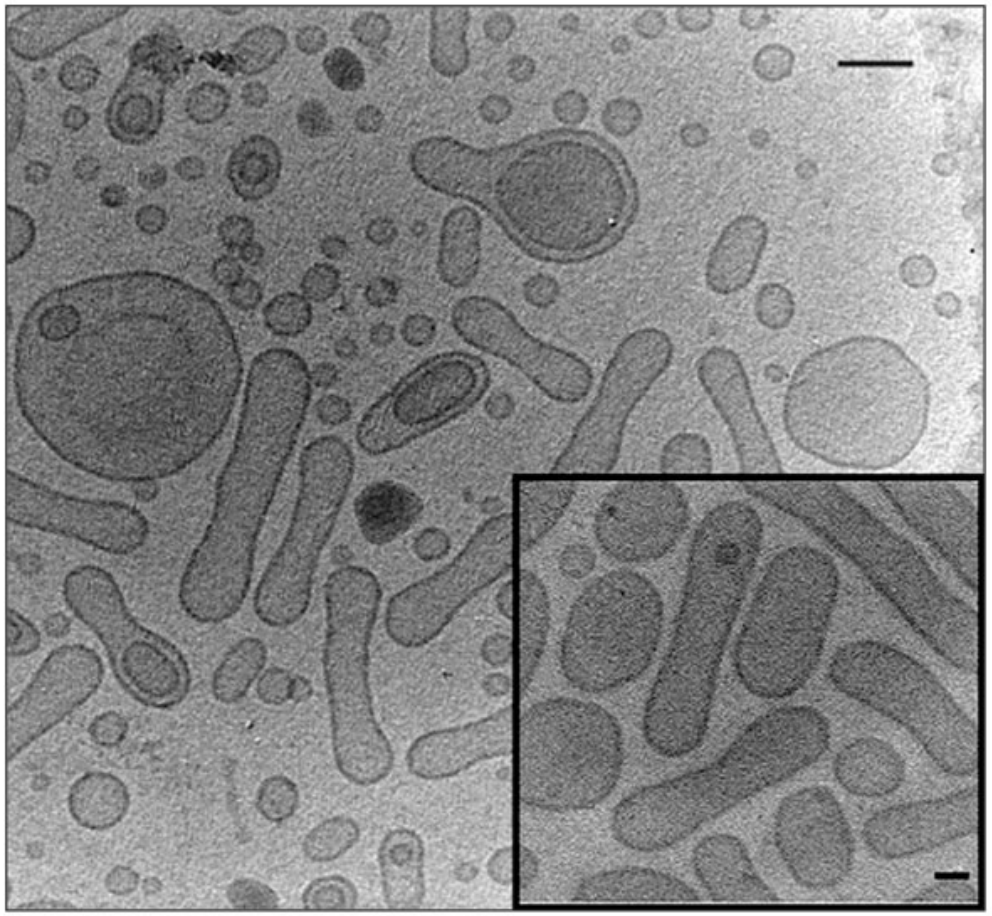


$V_c > 10^4$ K/s (cooling rate)



Cryo Electron Microscopy

Frozen hydrated specimen

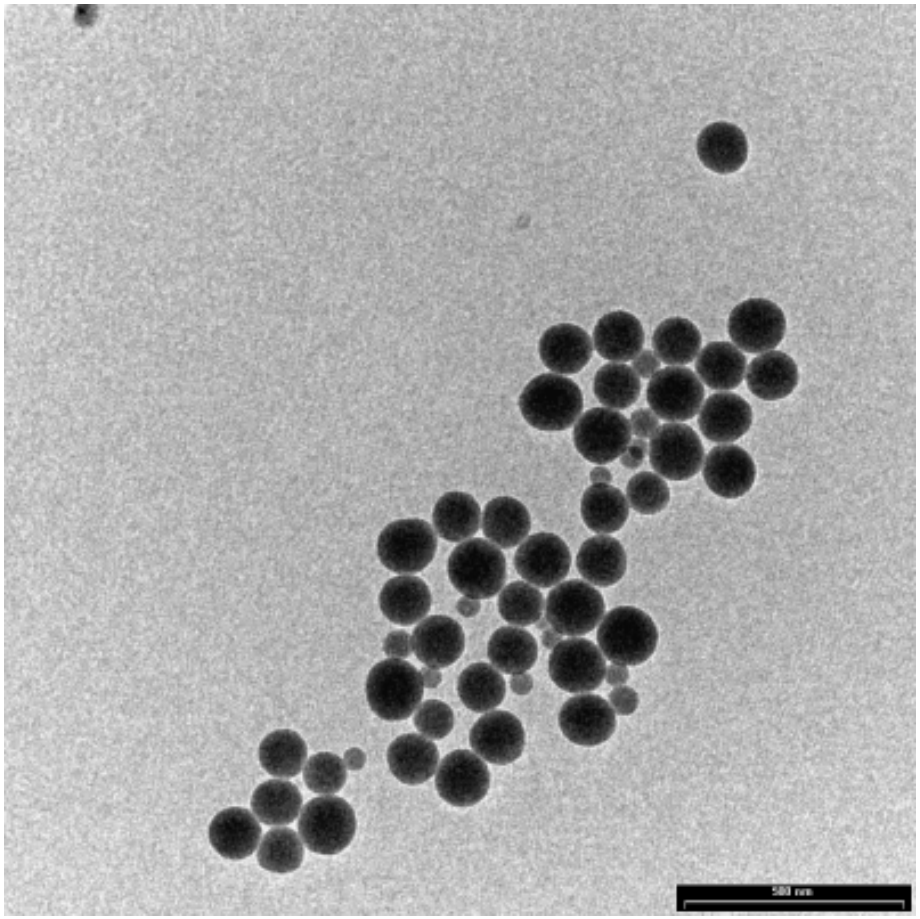


Polymerosomes
EG_{16} PS_{50} EG_{16}

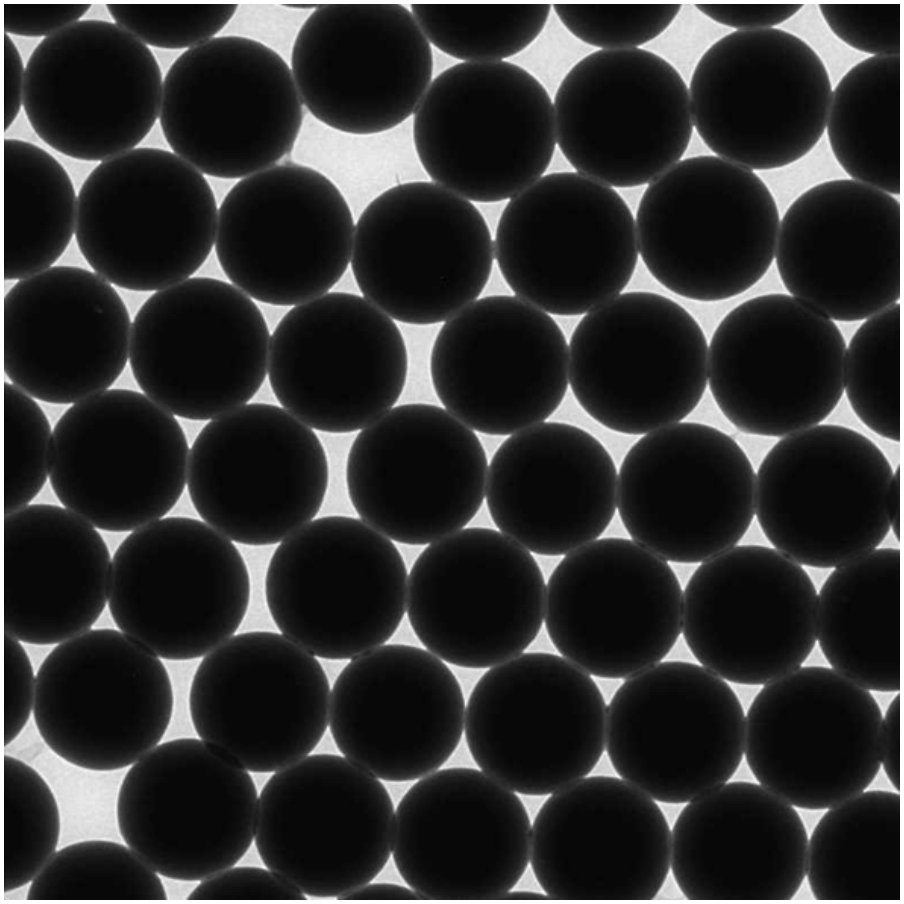
ALESSANDRO NAPOLI, MASSIMILIANO VALENTINI, NICOLA TIRELLI, MARTIN MÜLLER and JEFFREY A. HUBBELL
Nature Materials 3, 183–189 (2004)

Particle morphologies

Latex particles

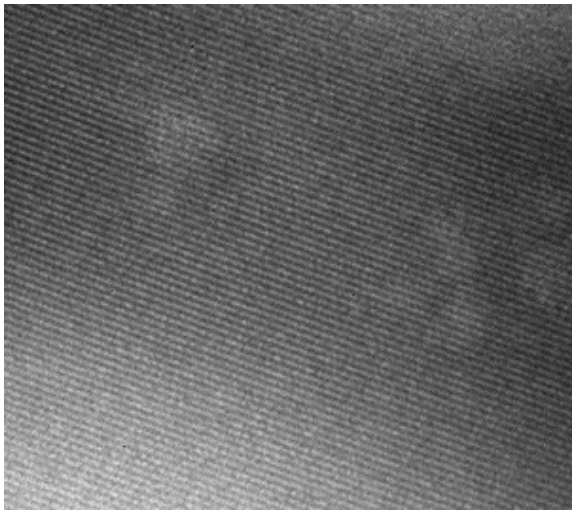


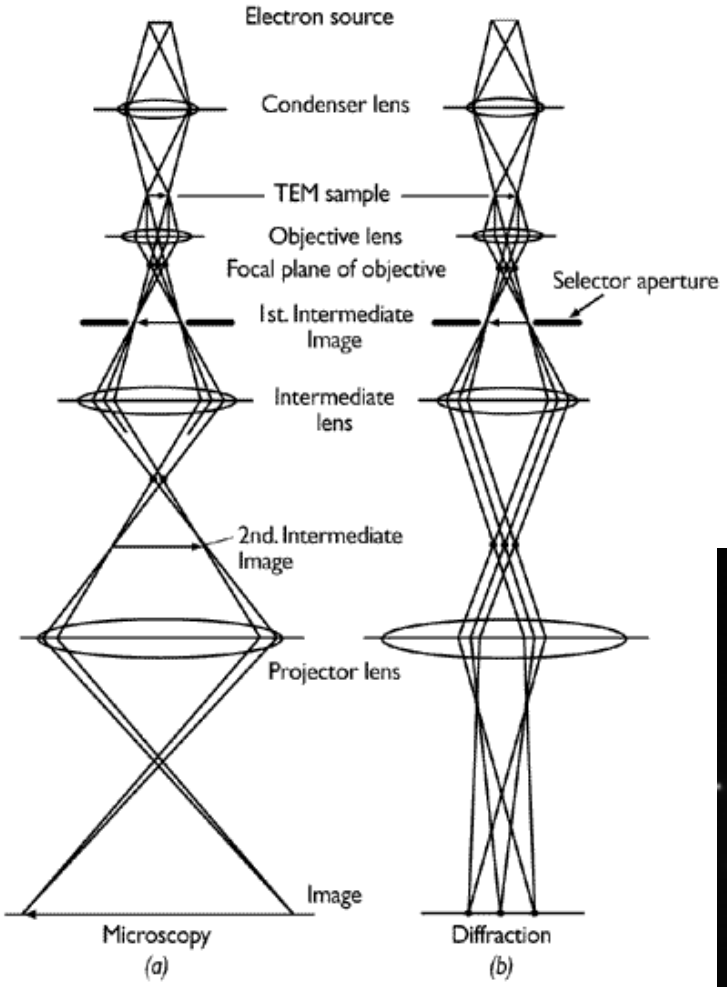
bimodal

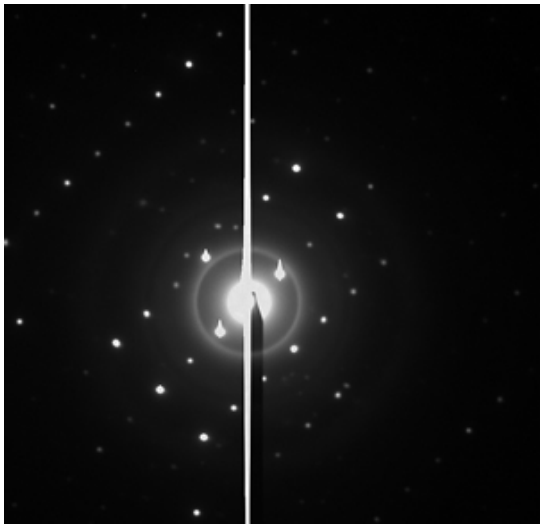


unimodal

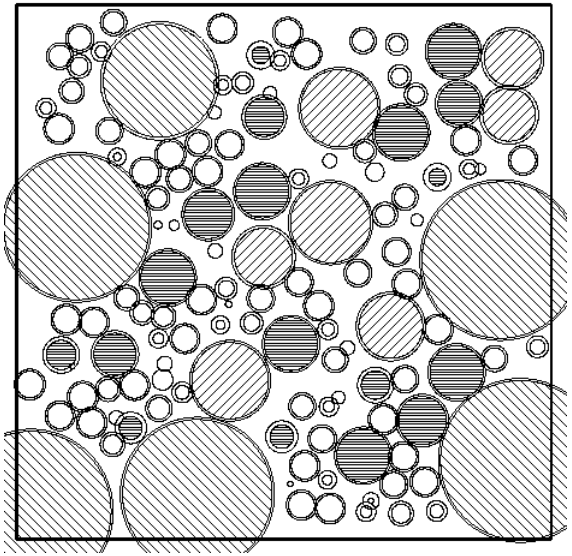
Transmission Electron Microscope



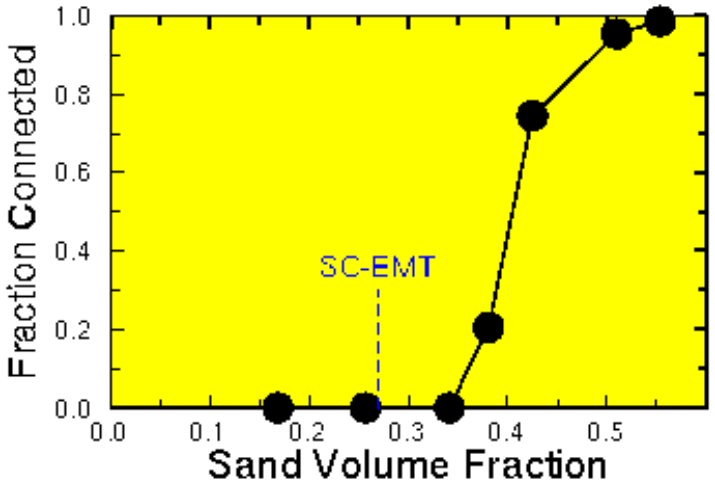




Percolating structures
(Sand particles in cement)

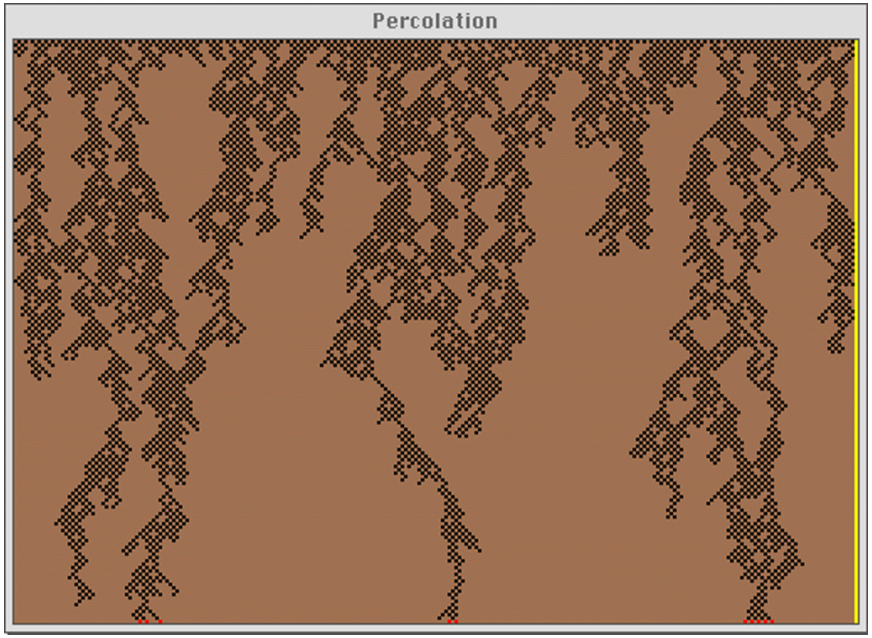


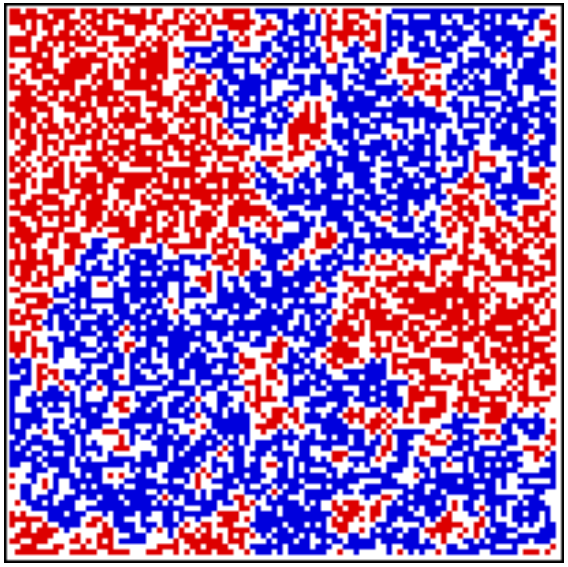
Percolation



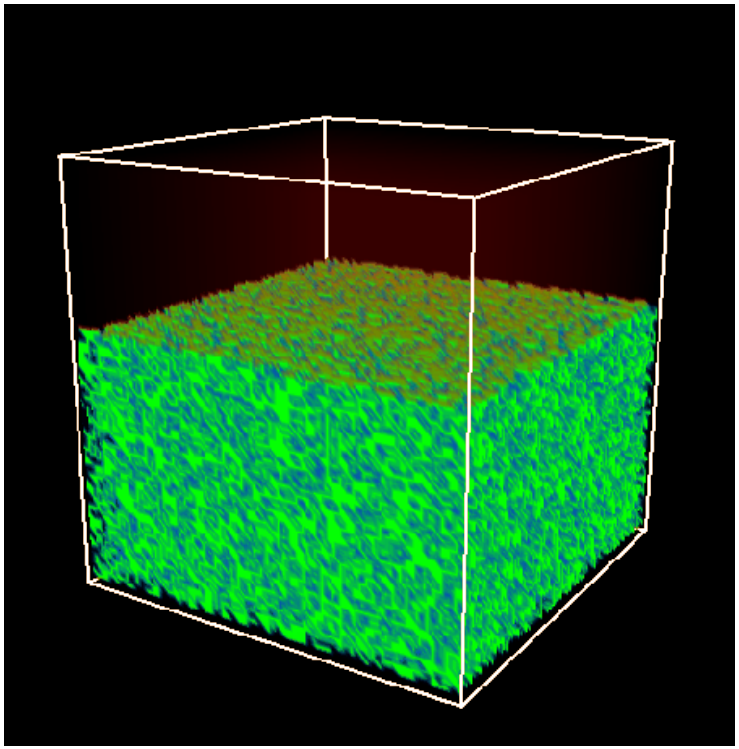
Percolation threshhold

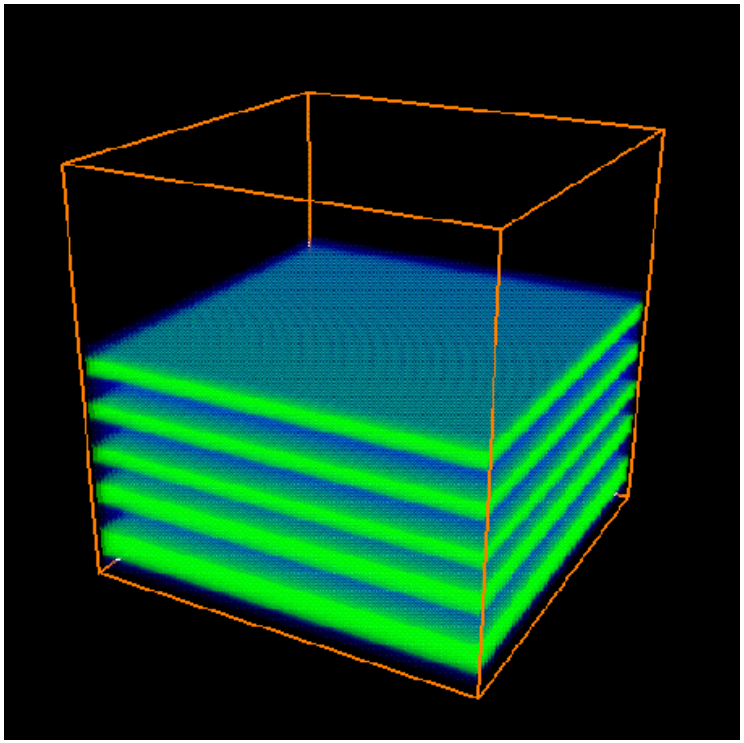
Percolating structures



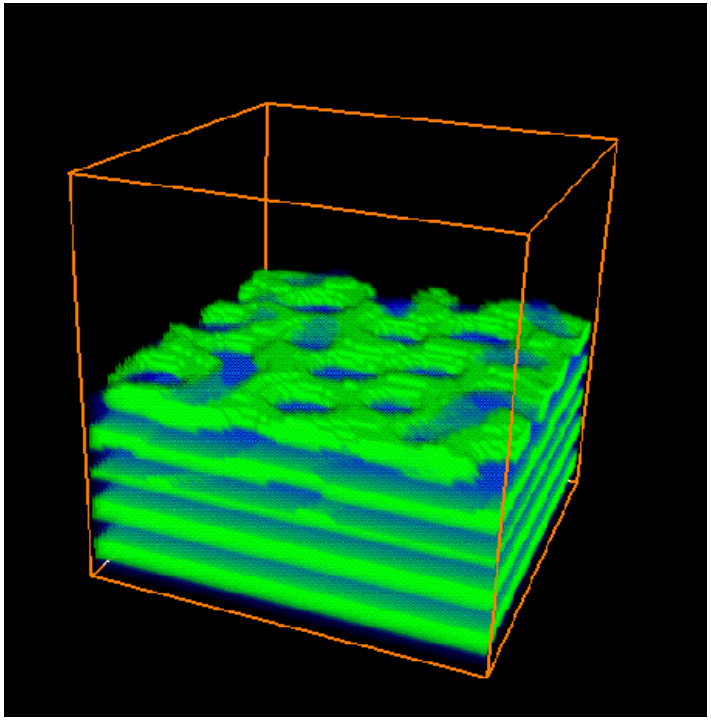


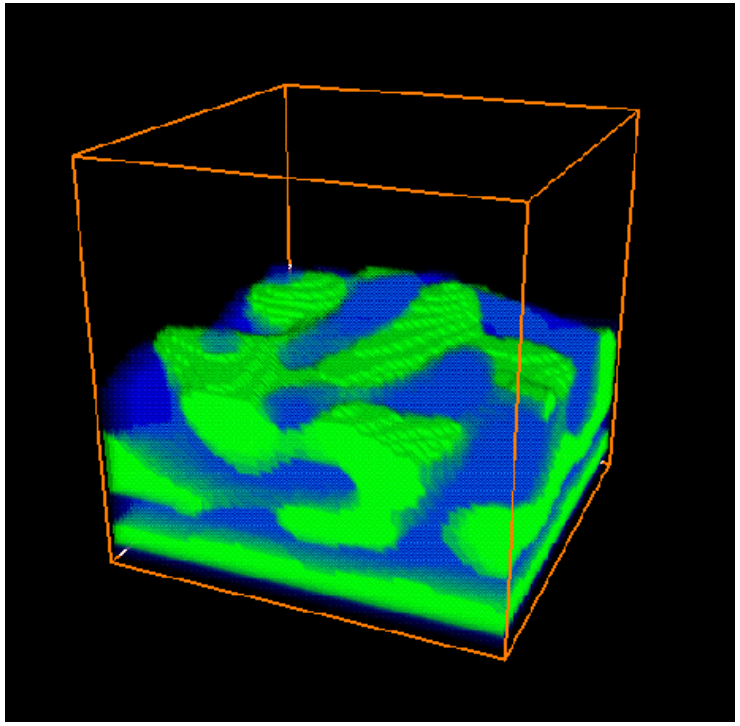
Surface induced structures





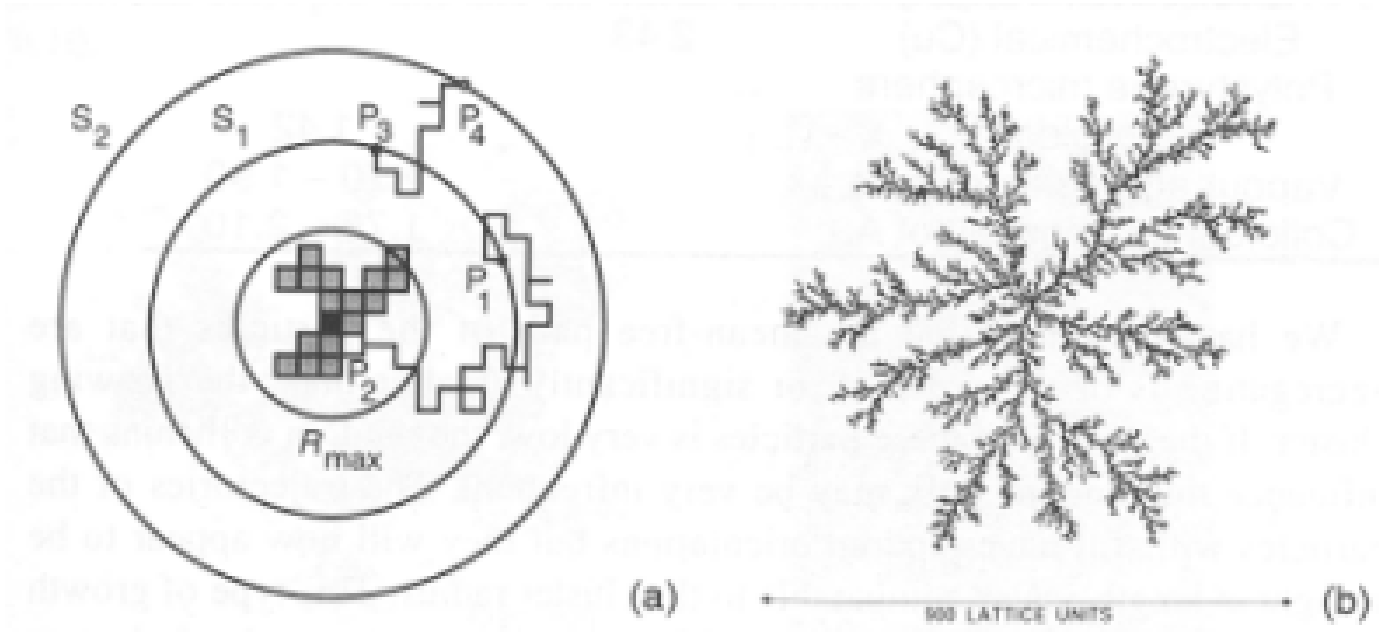
Surface induced structures



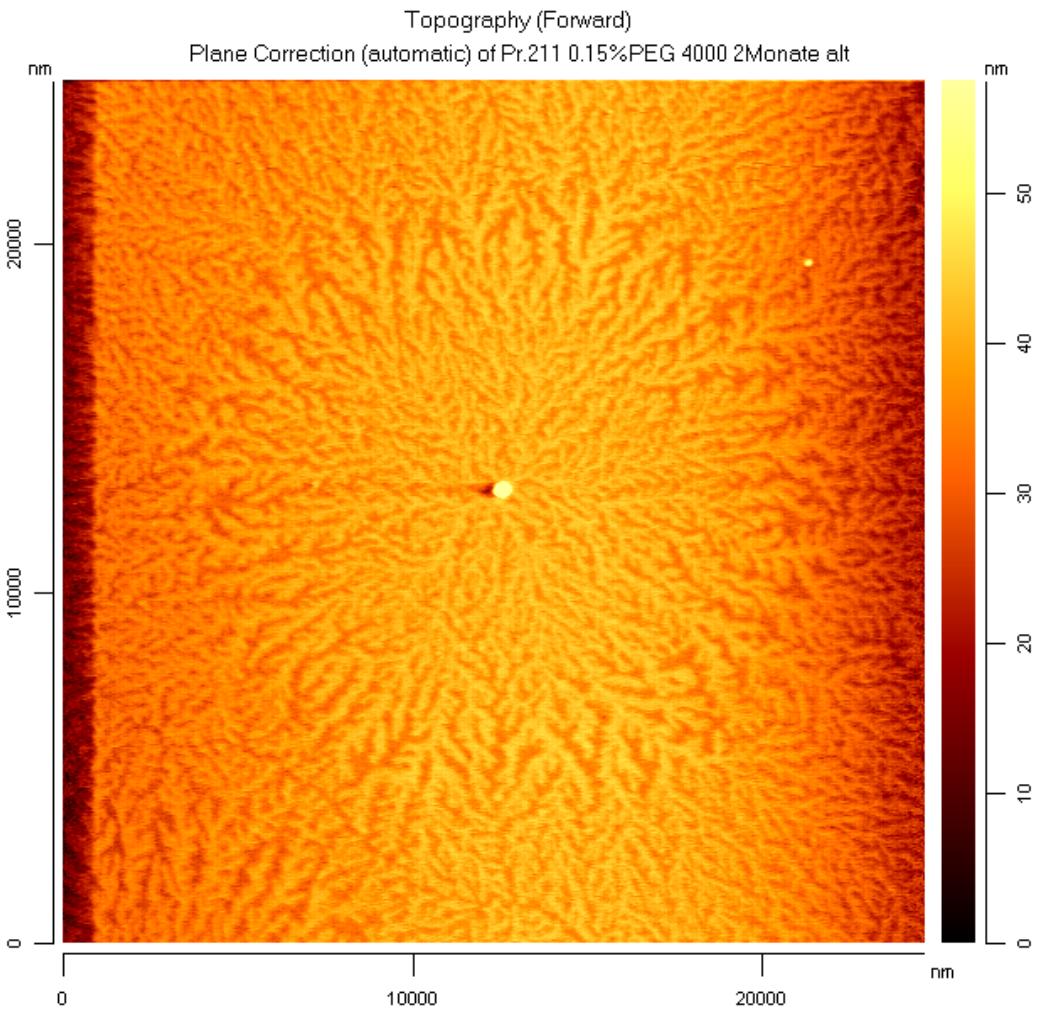


Fractal structures

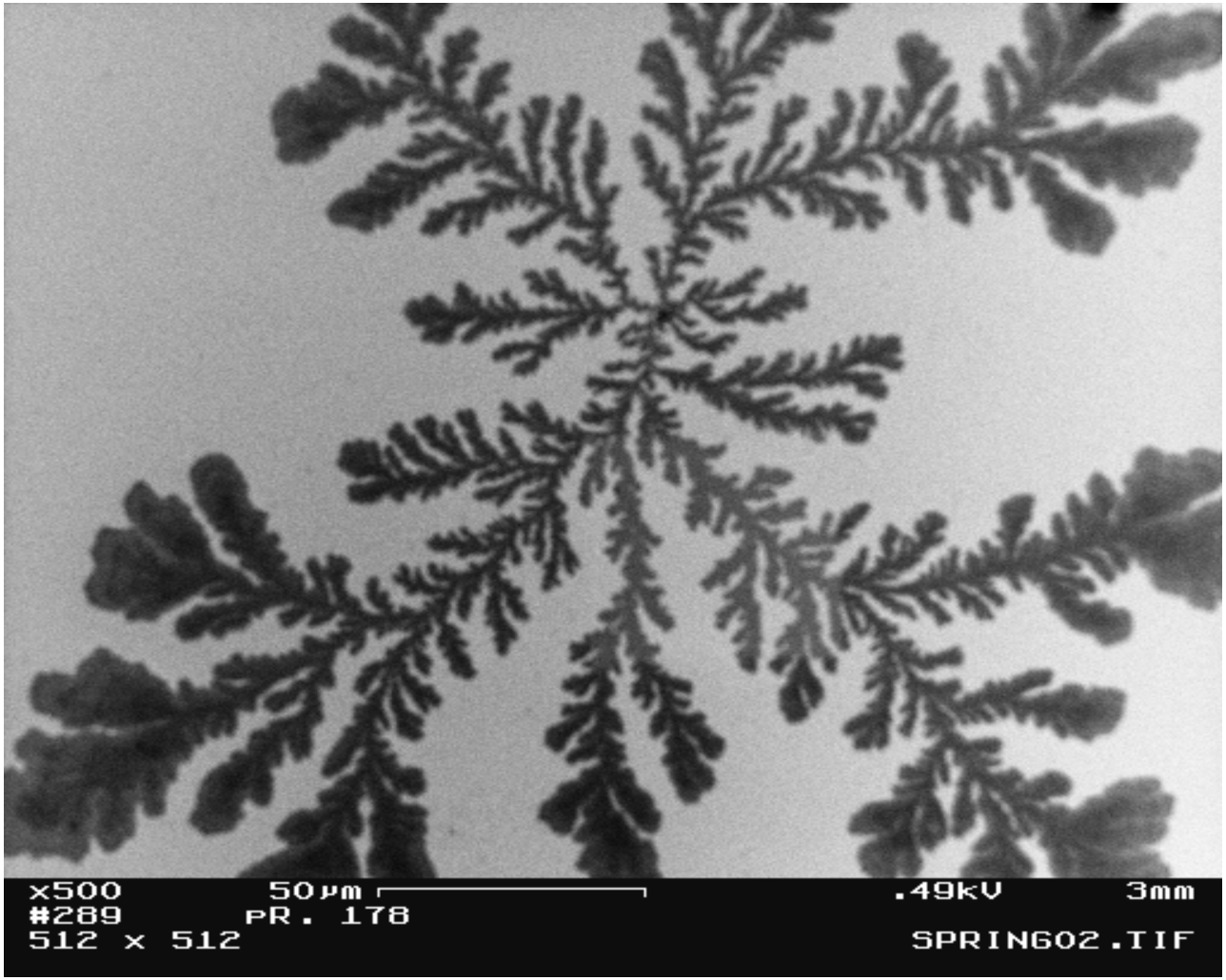
DLA Clusters



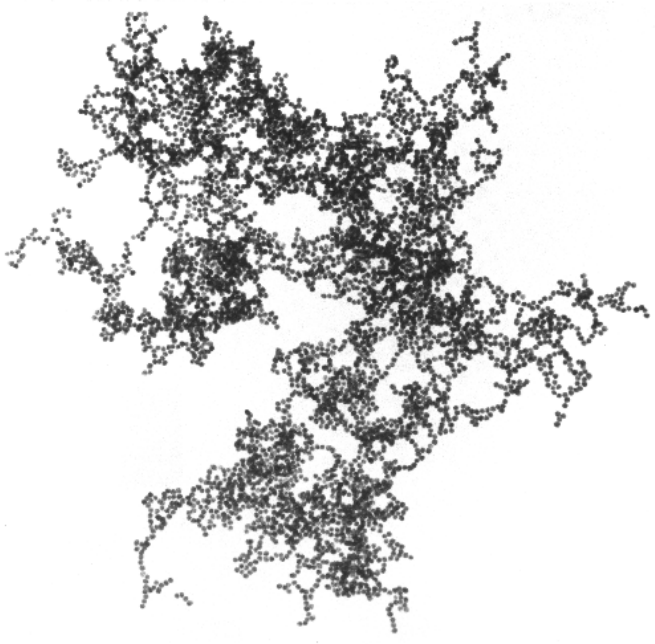
DLA Clusters



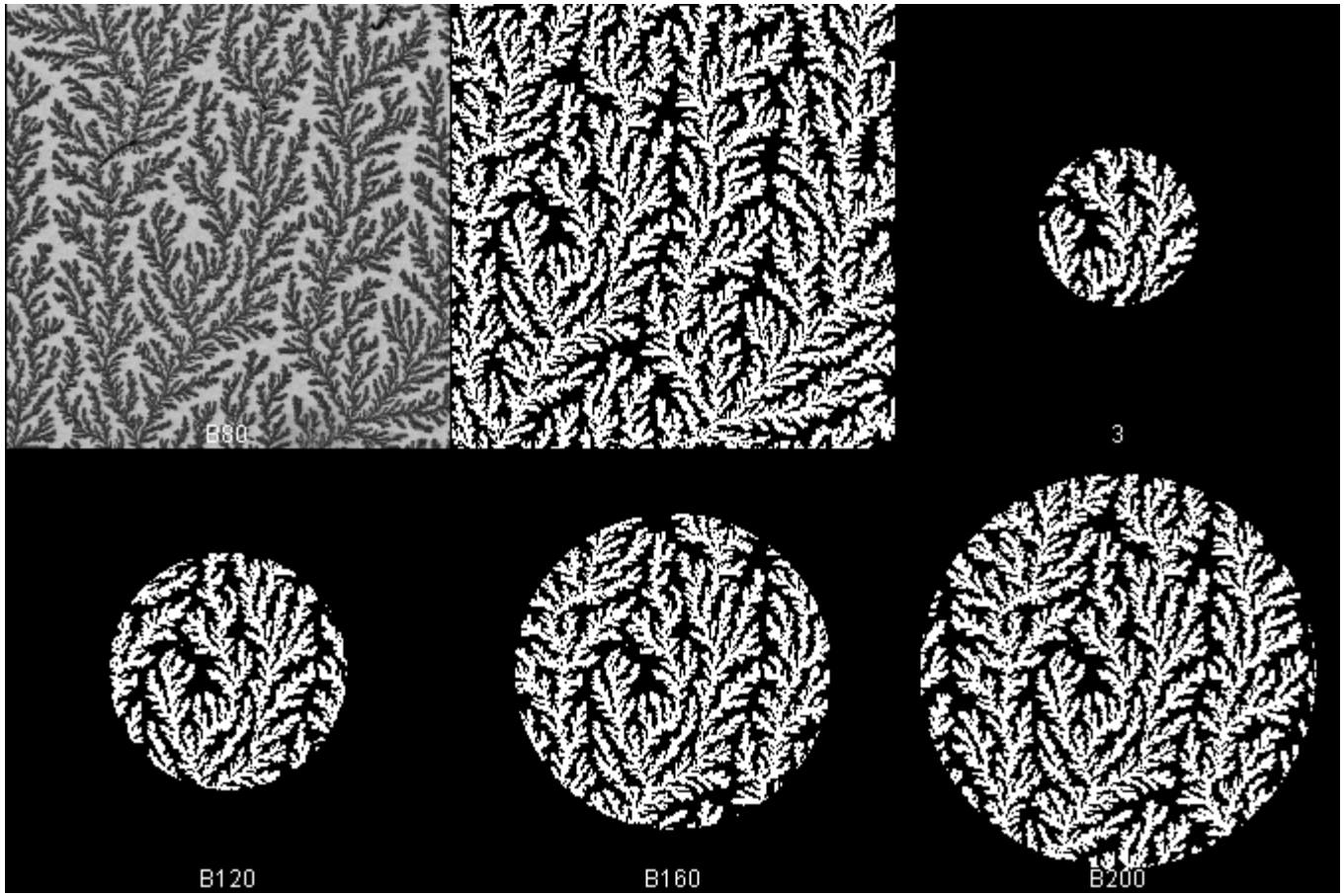
DLA Clusters



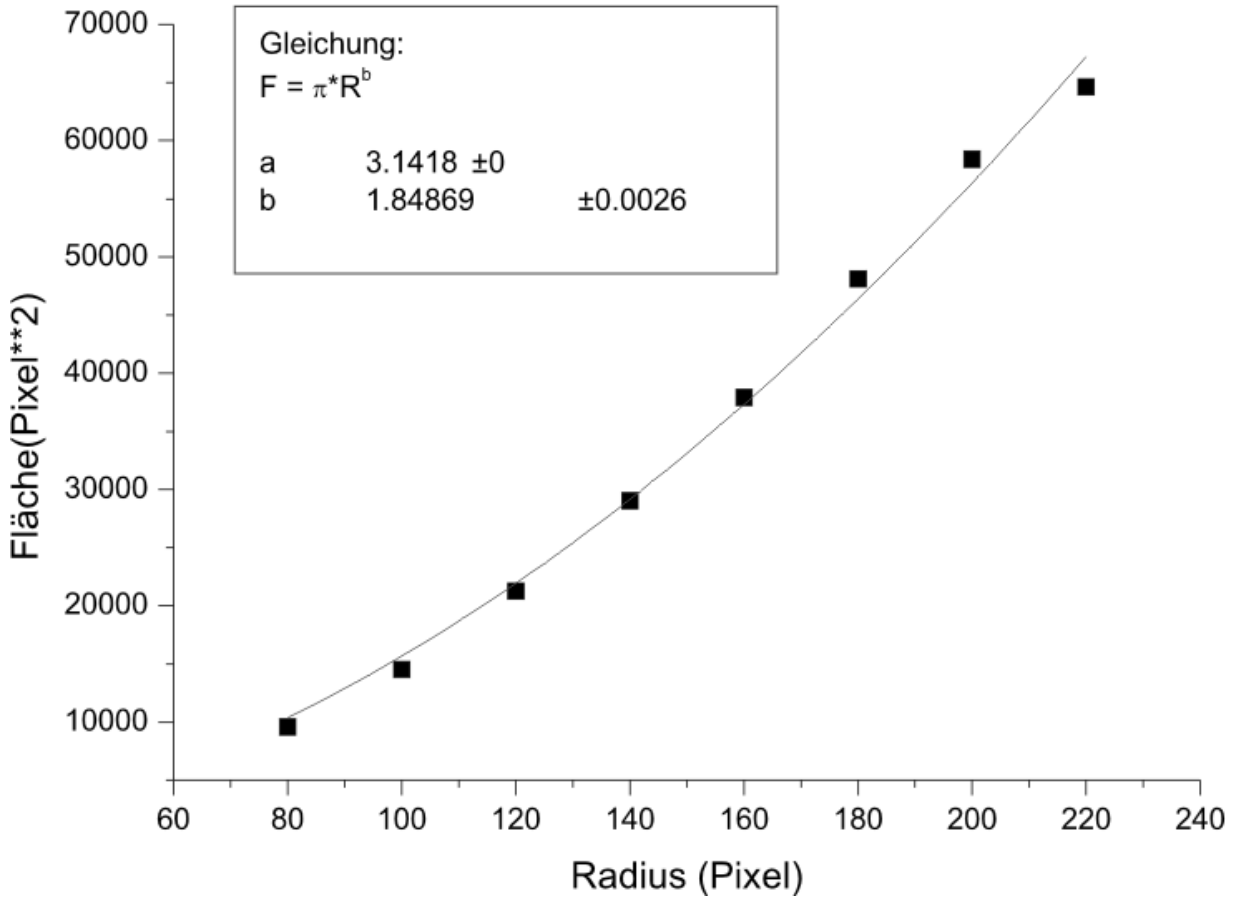
DLA Clusters in nature



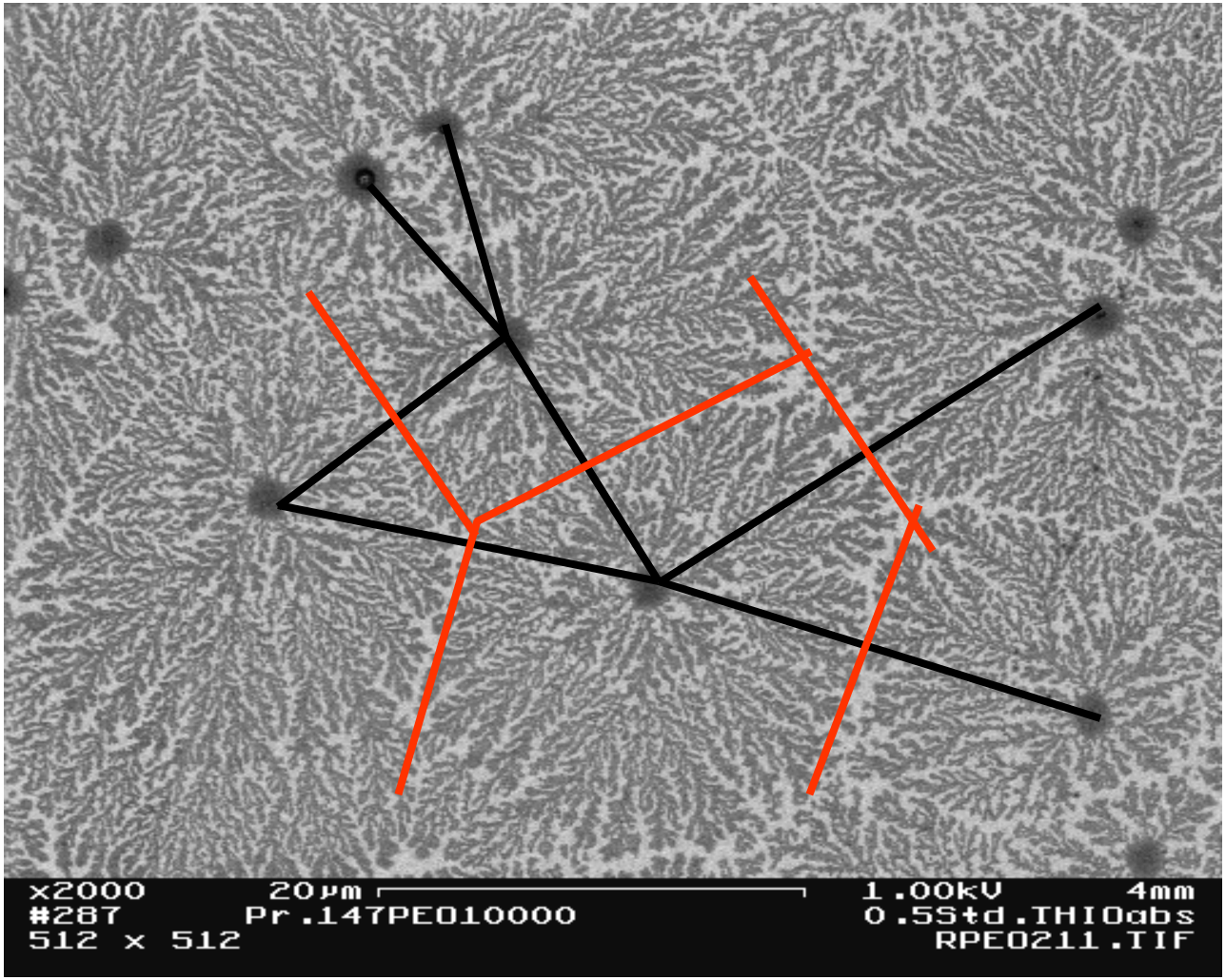
Fractal characterisation



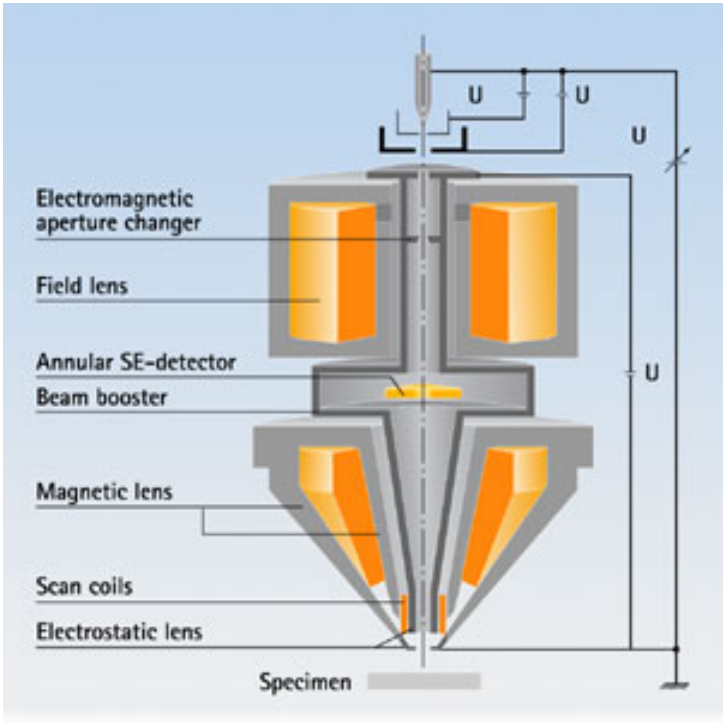
Fractal characterisation



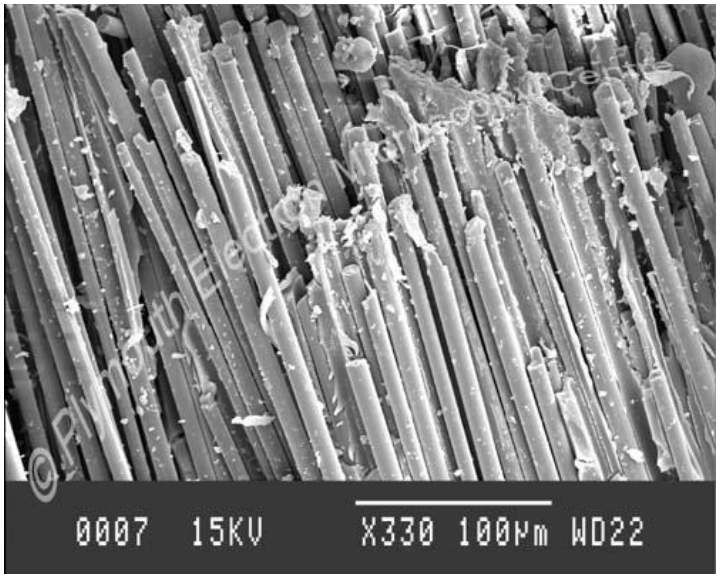
Voronoi Polyhedra

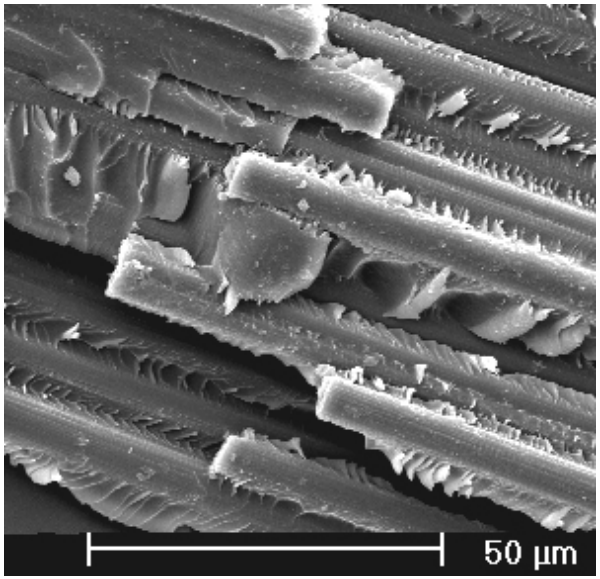


Low Voltage Scanning Electron Microscope



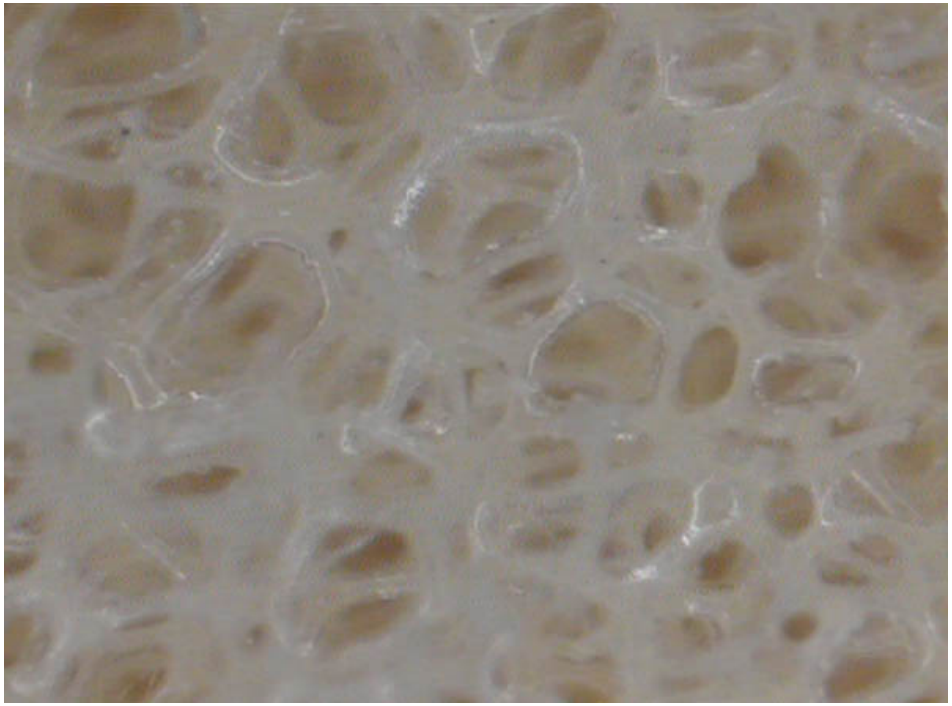
Carbon fibres composites



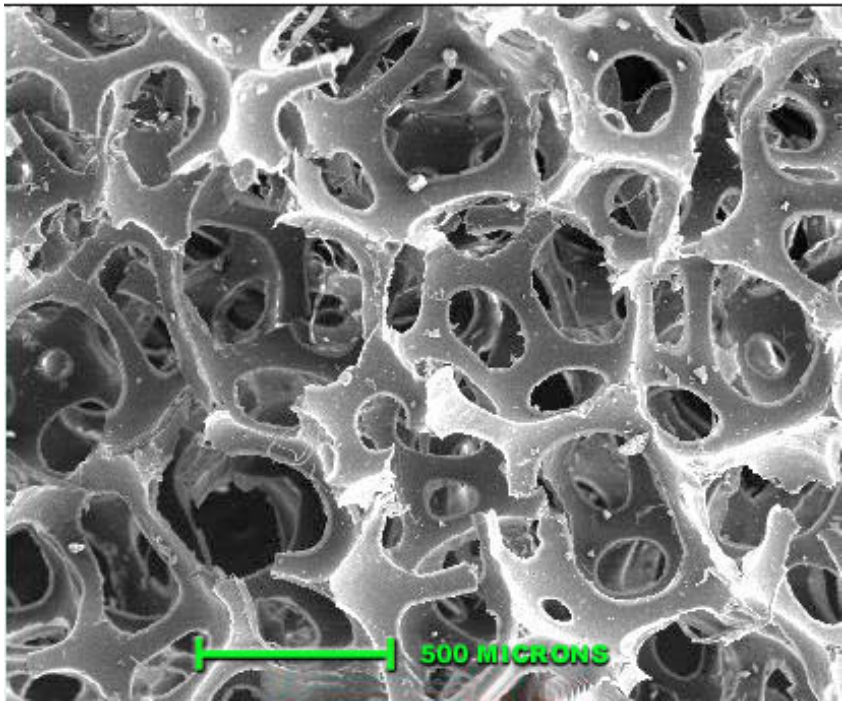


Fracture surfaces

Foam structures

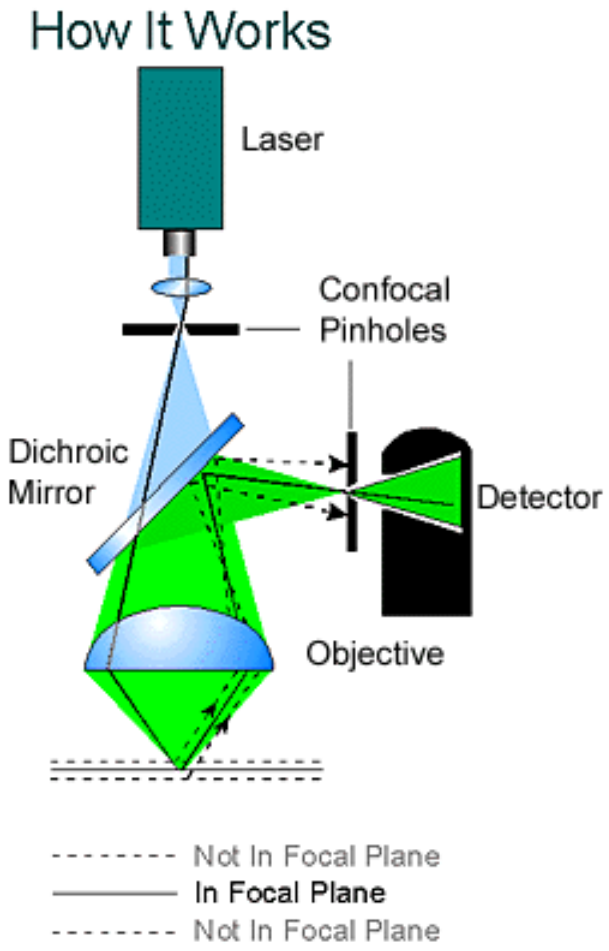


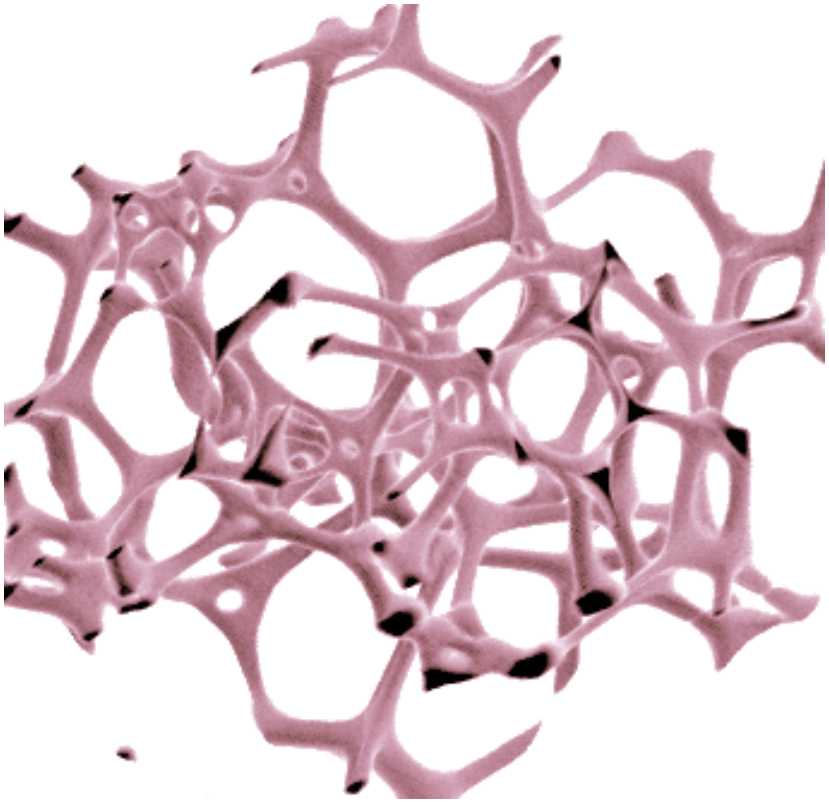
Light microscope



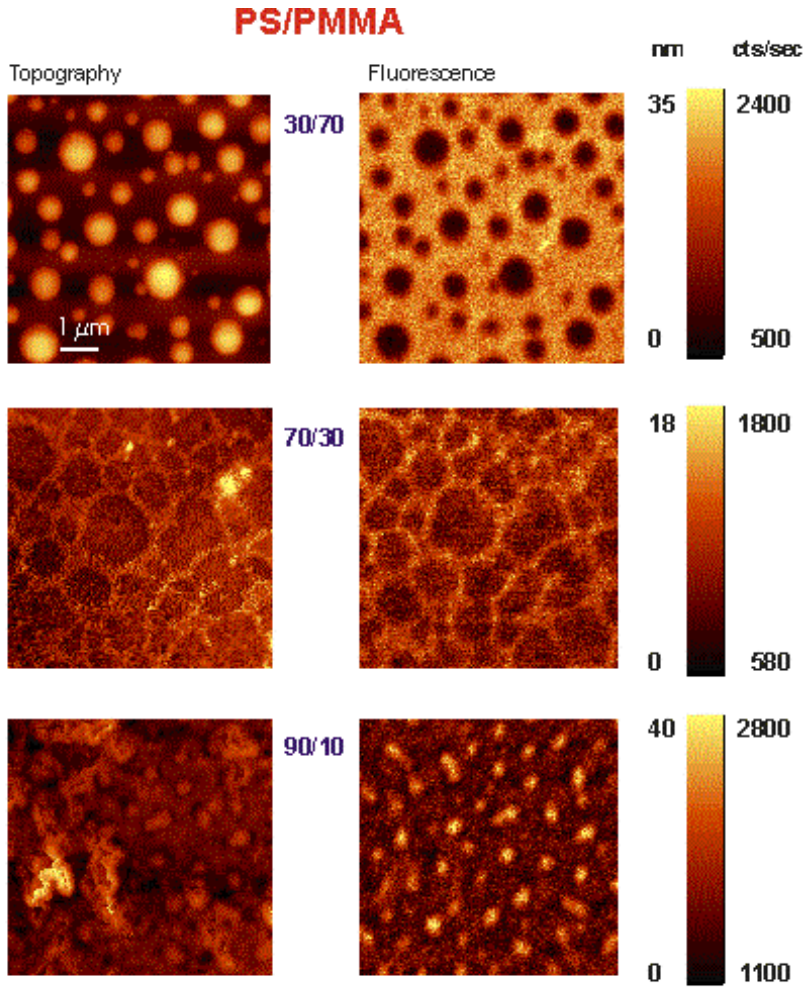
Scanning Electron Microscope

3 dimensional information by LSM



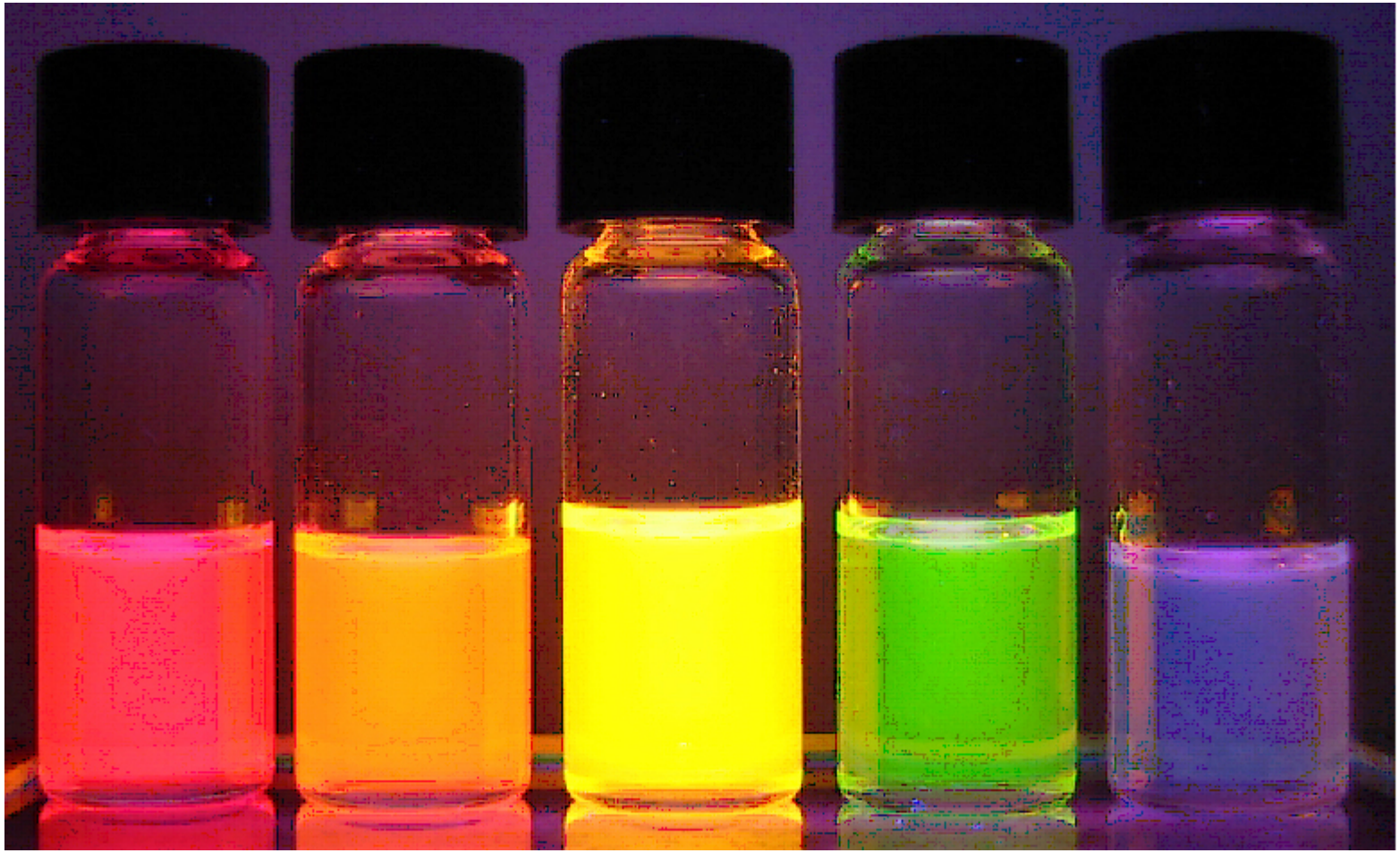


Fluorescence Microscopy



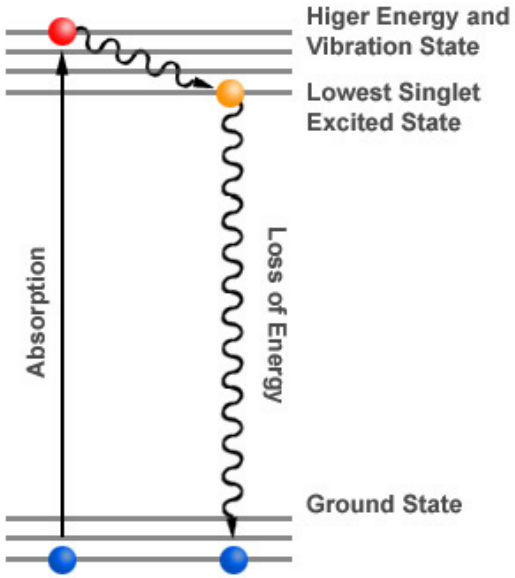
Phase characterisation in PS/PMMA blends

Fluorescence Microscopy



Fluorescence dyes

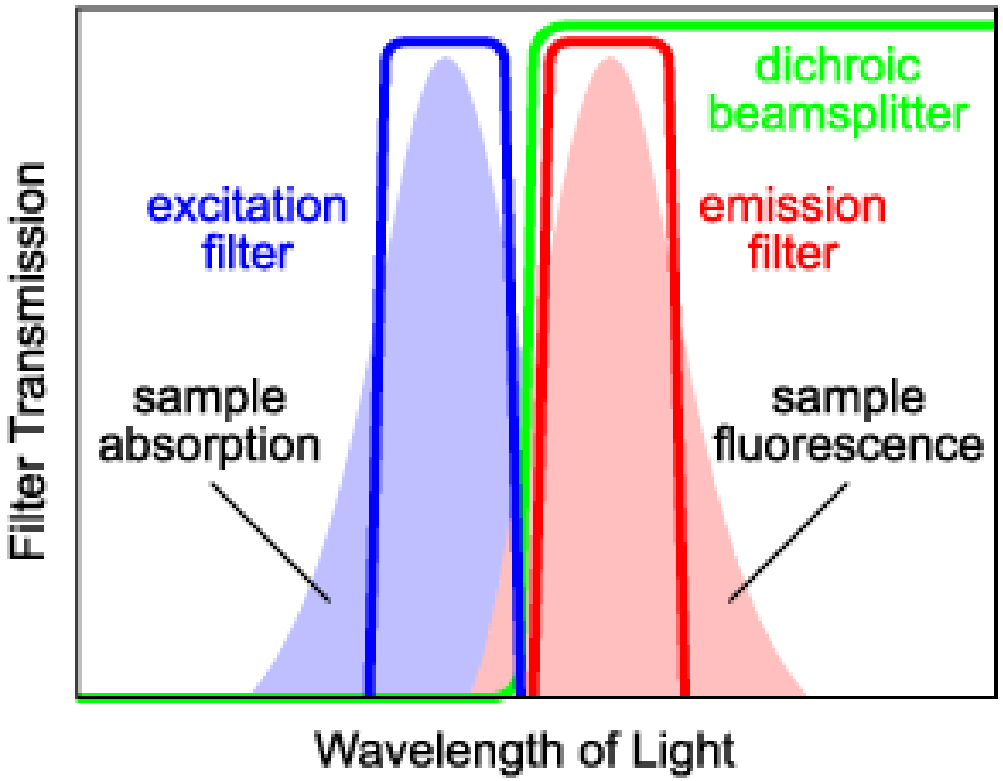
Fluorescence Microscopy



Fluorescence
Within femtoseconds after light excites the fluorophore at an appropriate wavelength, its electrons jump from the ground state to a higher vibrational state. Within picoseconds these electrons decay to the lowest excited state, and then decay more slowly (nsec) back to the ground state with the emission of a photon whose wavelength is longer than the exciting wavelength. Click to continue >>

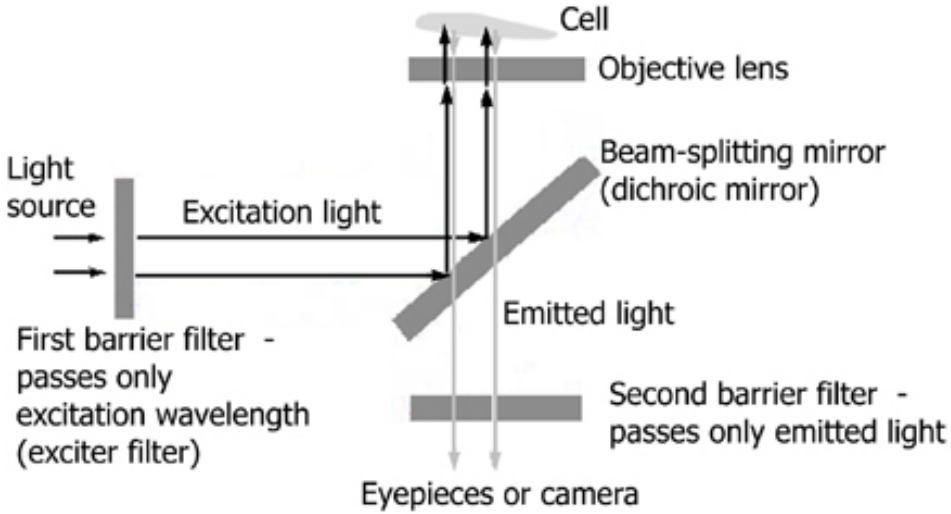
Fluorescence dyes – the physical principle

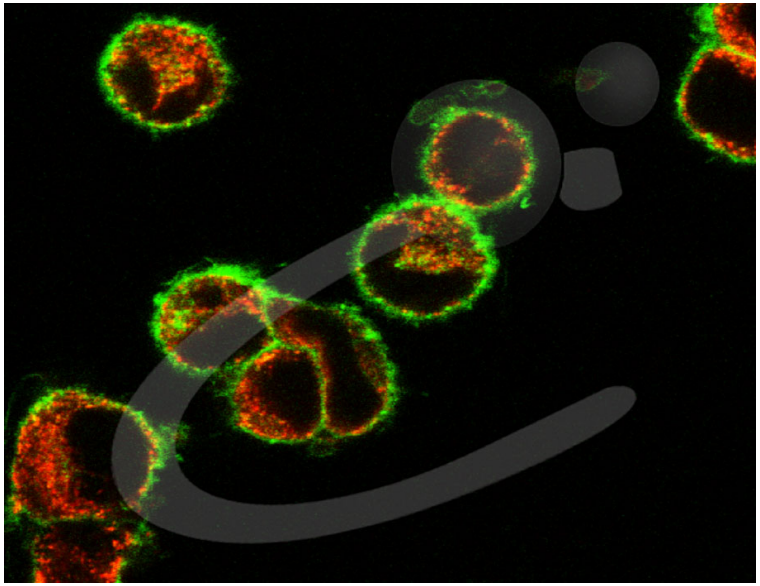
Fluorescence Microscopy



Fluorescence absorption – emission – optical elements

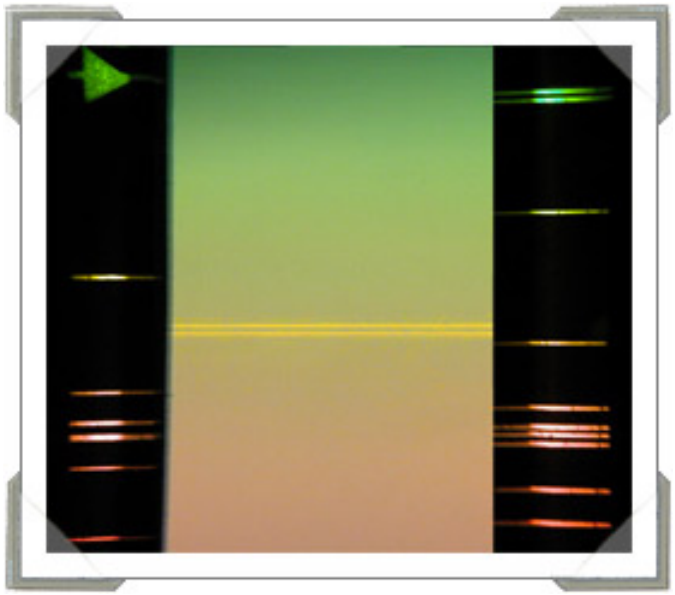
Fluorescence Microscopy

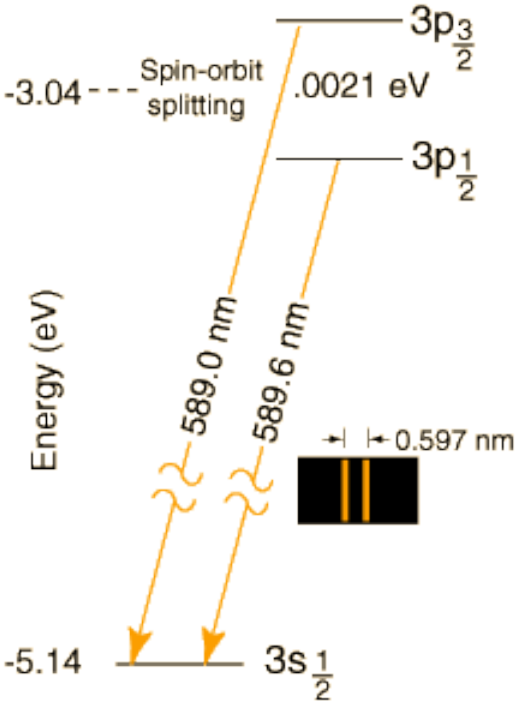




Fluorescence microscop image

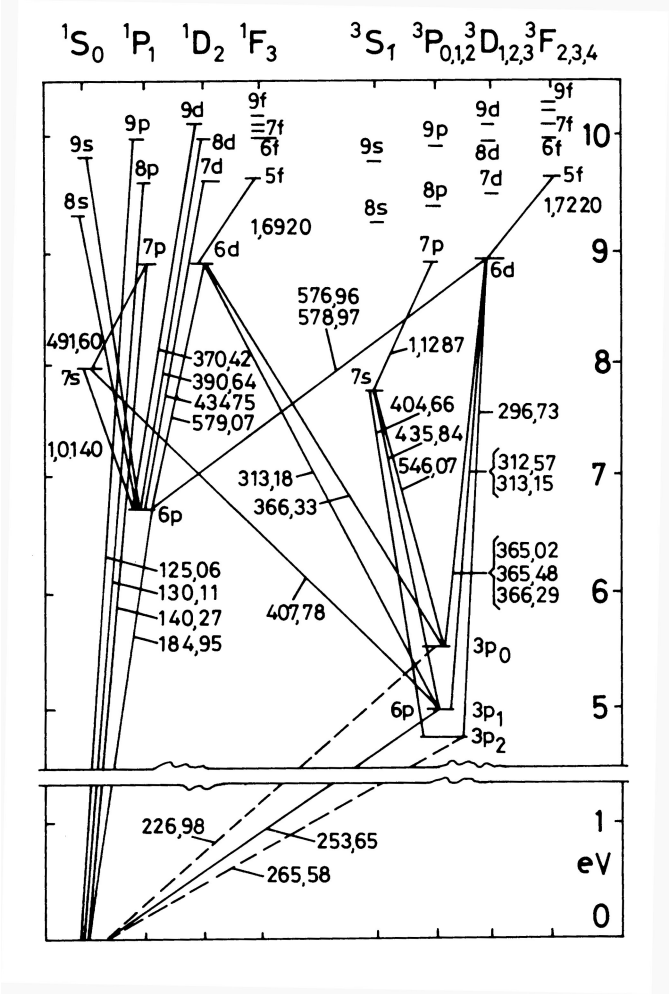
Fluorescence Microscopy

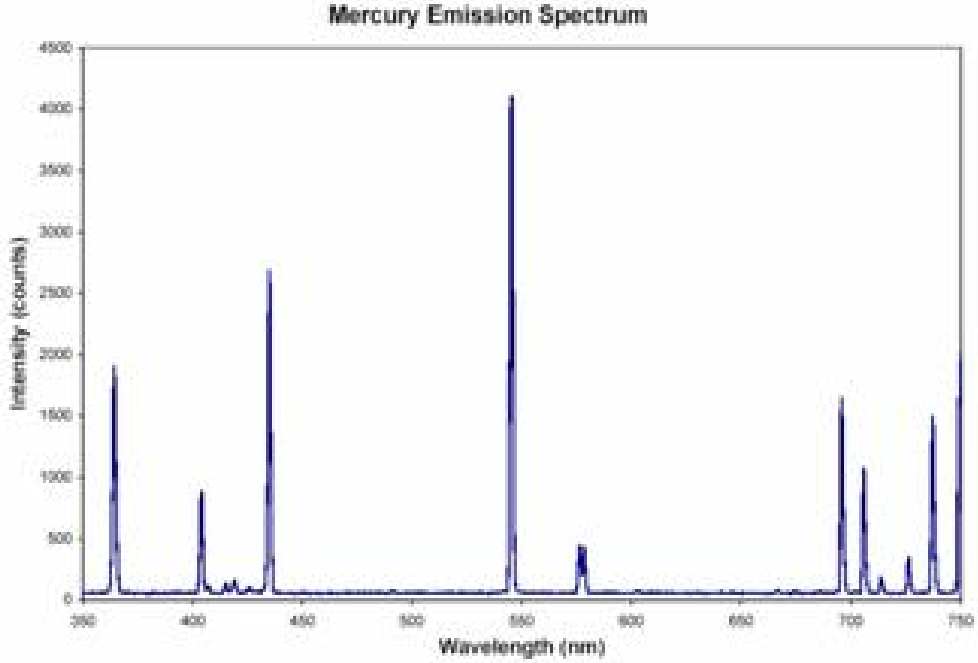




Na Emission spectra

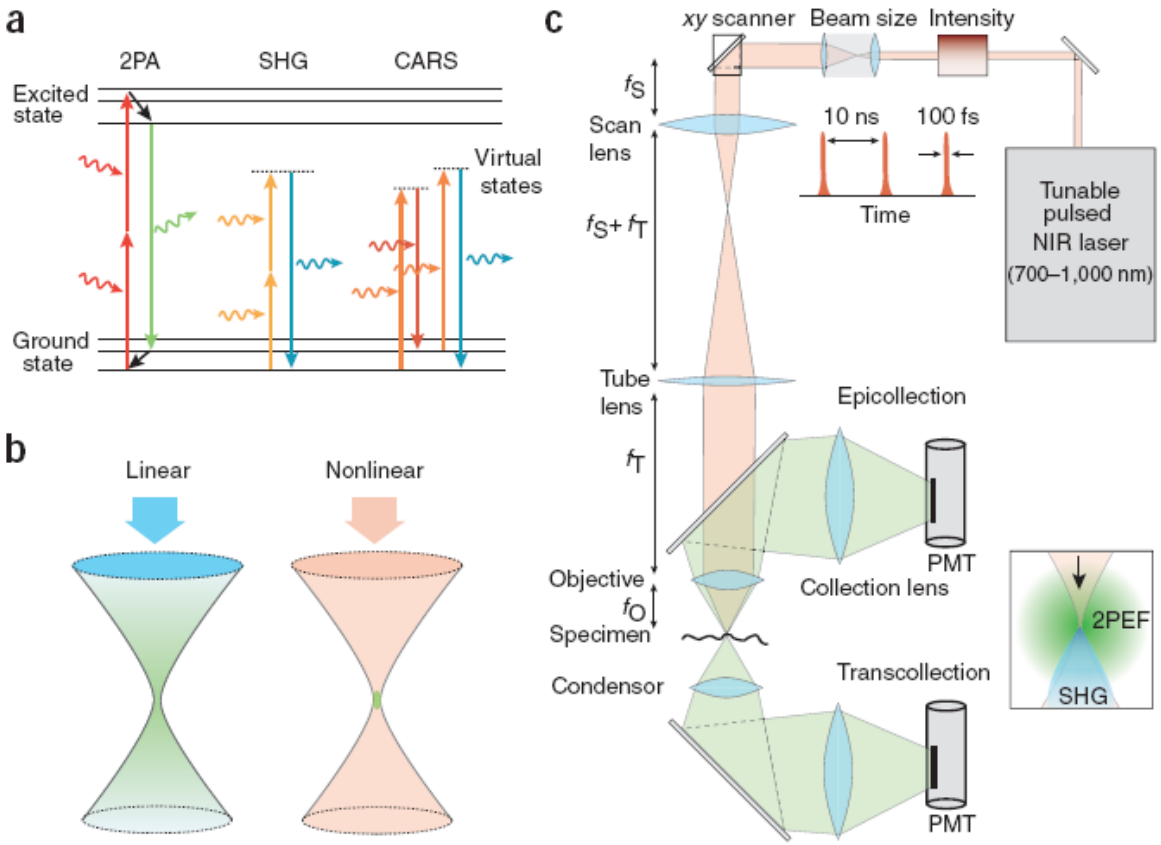
Fluorescence Microscopy





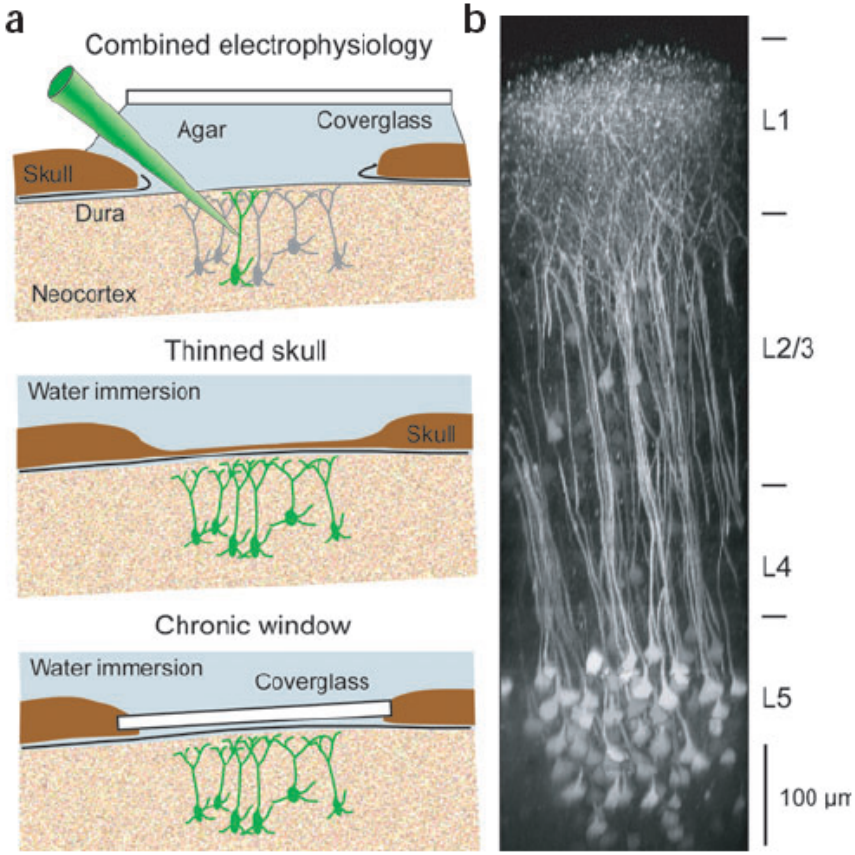
Hg emission spectra

Two-Photon Fluorescence Microscopy Principles



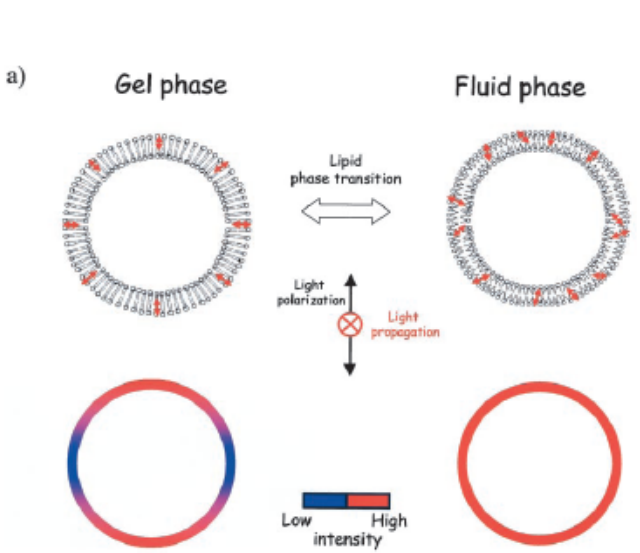
Helmchen, Denk, Nature Methods 2(12), (2005) , 932

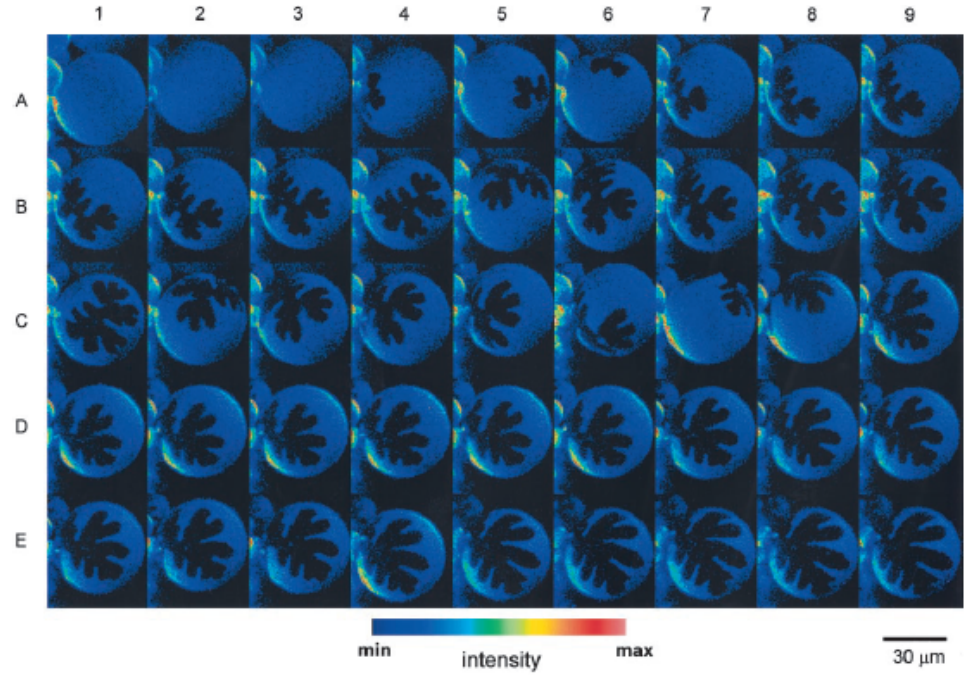
Two-Photon Fluorescence Microscopy Applications



Helmchen, Denk, Nature Methods 2(12), (2005) , 932

Two-Photon Fluorescence Microscopy





Phase separation and diffusion limited growth in Phospholipid membranes

Bagatolli, Gratton , Biophysical Journal **78**. (2000), 290

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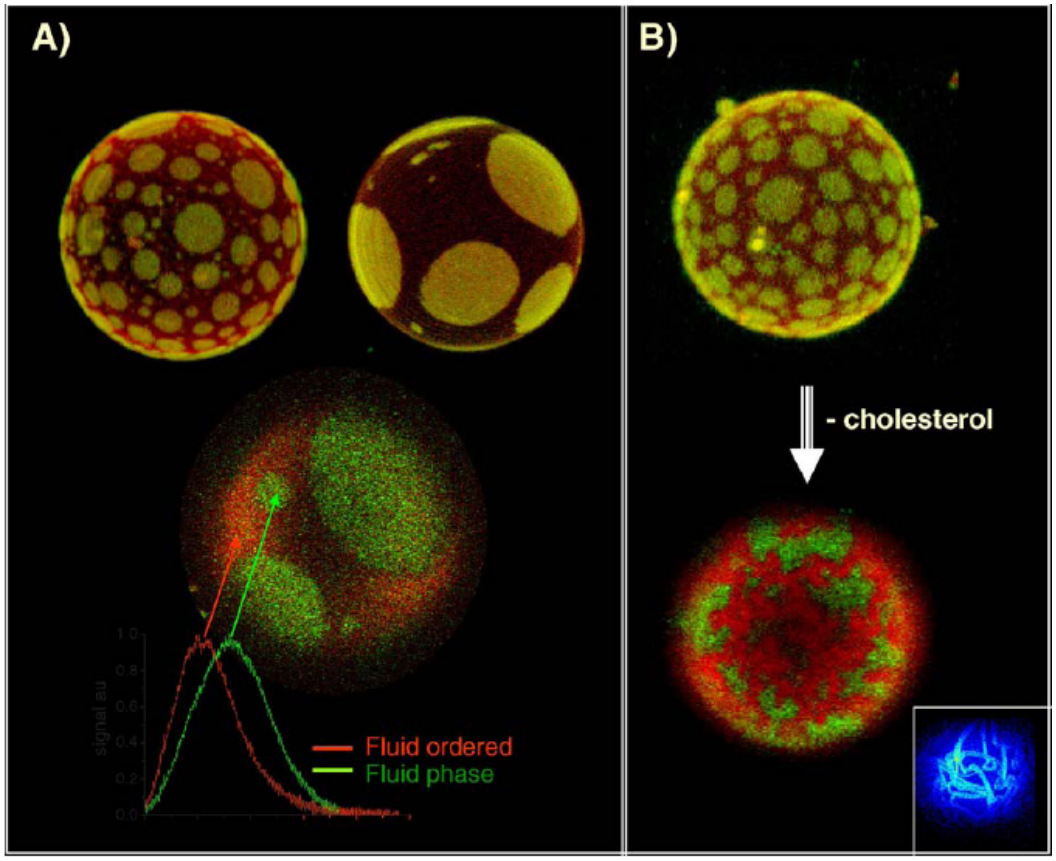

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Ein gesundes und erfolgreiches Jahr