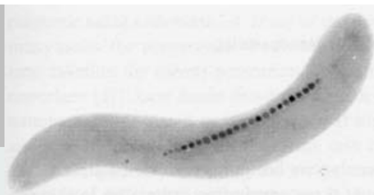
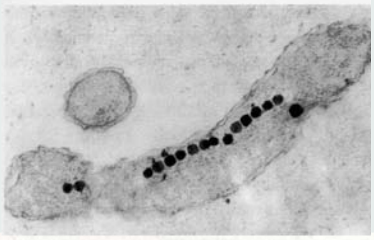
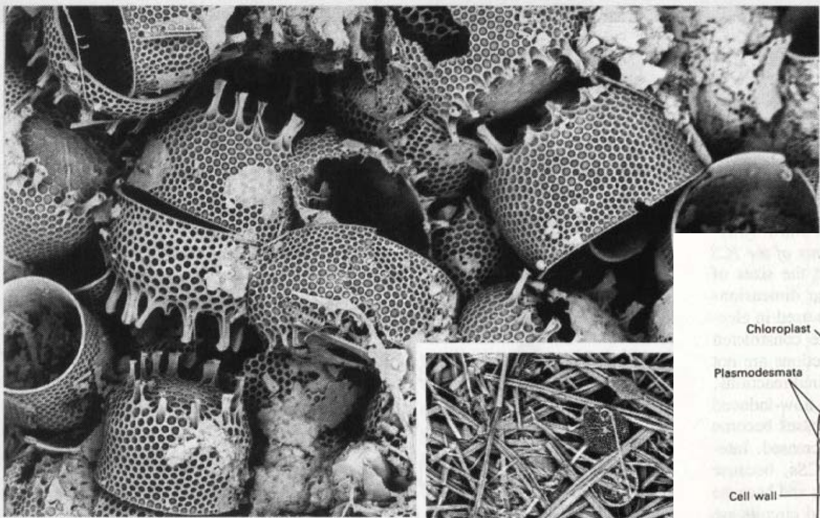
Hierarchical Organizations







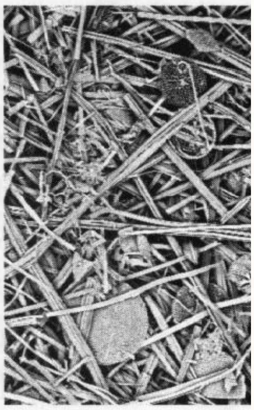
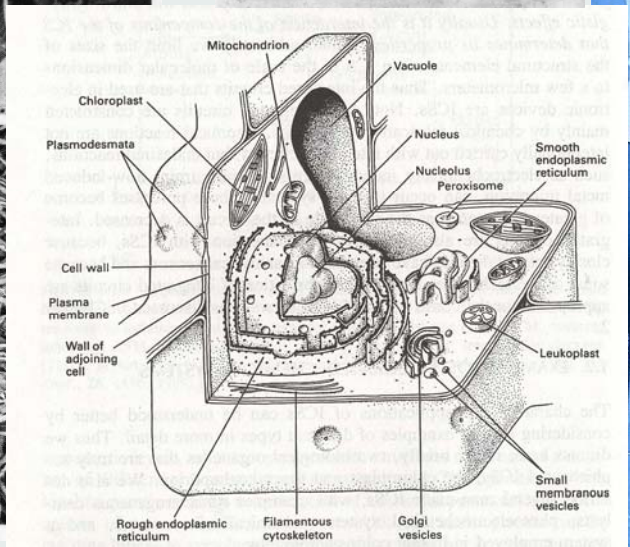


Figure 1 Evidence of the 'fall dump' of giant diatoms identified by Kemp *et al.*[1]. Above, a sediment layer from the Gulf of California dominated by cell walls of *Stephanopyxis palmeriana* (diameter < 70 μm). Right, a sediment layer from the Southern Ocean, showing a tangled mass of the rod-shaped species *Thalassiothrix antarctica*, which grows up to 4 mm in length. (Courtesy of A. E. S. Kemp.)

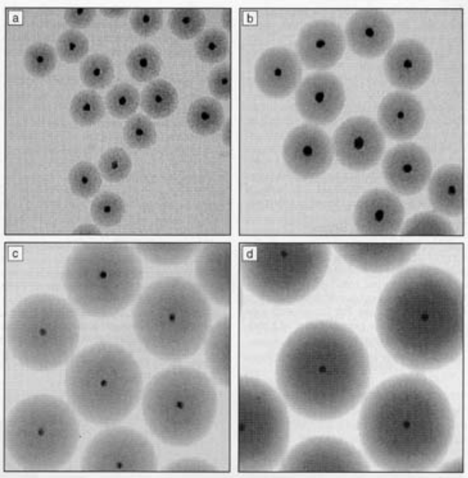


Metals NPs in Solutions and in Polymers

P. Mulvaney, MRS Bull. 2001, 26, 1009

$$R = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2},$$

Figure 5. The transmitted colors of a series of gold particle films with decreasing particle spacing. The gold core particles are 15 nm in diameter; the shell thicknesses are, from left to right, 17.5 nm, 12.5 nm, 4.6 nm, 2.9 nm, 1.5 nm, 1.0 nm, 0.5 nm and 0 nm. Films are each 1 cm × 3 cm. The spectra shift smoothly between the two curves shown in Figure 3 as the spacing is varied.[9]



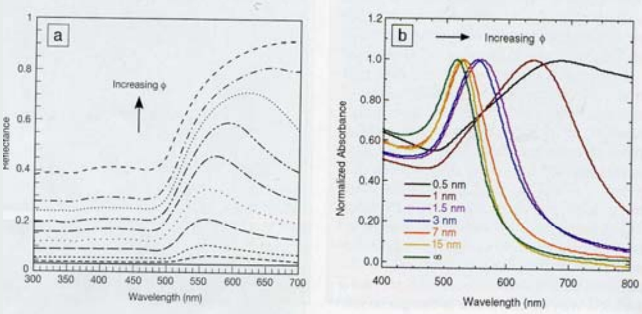


Figure 6. (a) Normalized reflectance spectra for Au@SiO$_2$ (gold concentrically coated by silica) films as a function of the volume fraction ϕ of Au. From the bottom curve upward, ϕ for each curve, respectively, is 0.01, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, and pure Au. (b) The normalized absorbance of a series of Au@SiO$_2$ films as a function of particle spacing.

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Figure 7. Photographs of aligned Ag nanorods in a poly(vinyl alcohol) film. The images shown are the transmitted colors with (a) unpolarized light, (b) horizontally polarized light, and (c) vertically polarized light.

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Fullerenes in CNTs

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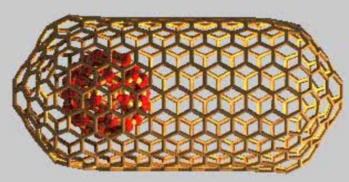


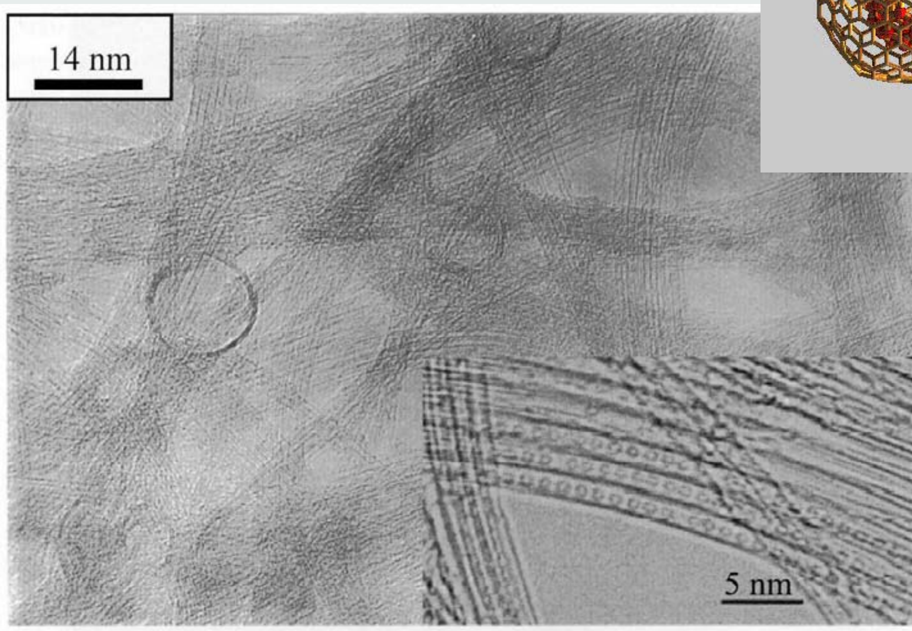
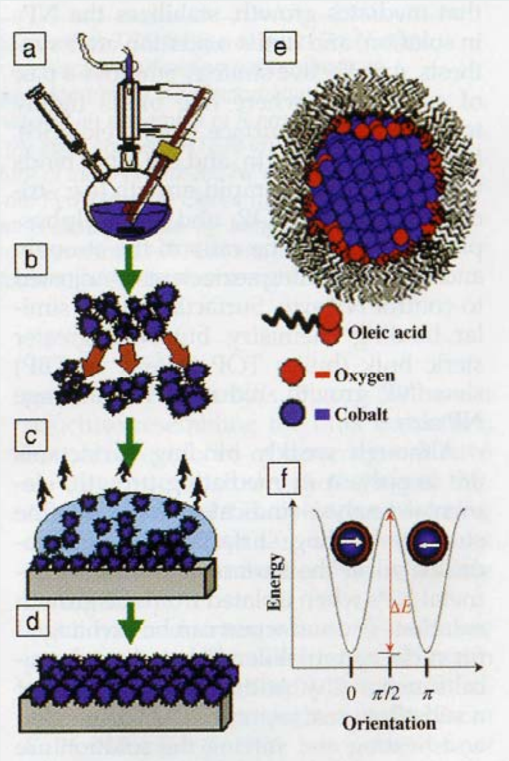


Fig. 8.6. HREM image of SWNTs obtained by arcing graphite electrodes filled with Ni and Y_2O_3 under a He atmosphere (660 Torr). Inset: The HREM image of encapsulated fullerenes inside the SWNTs; scale bar is 5 nm. Reproduced from ref. [45], with permission.

Selforganization of Magnet Colloids



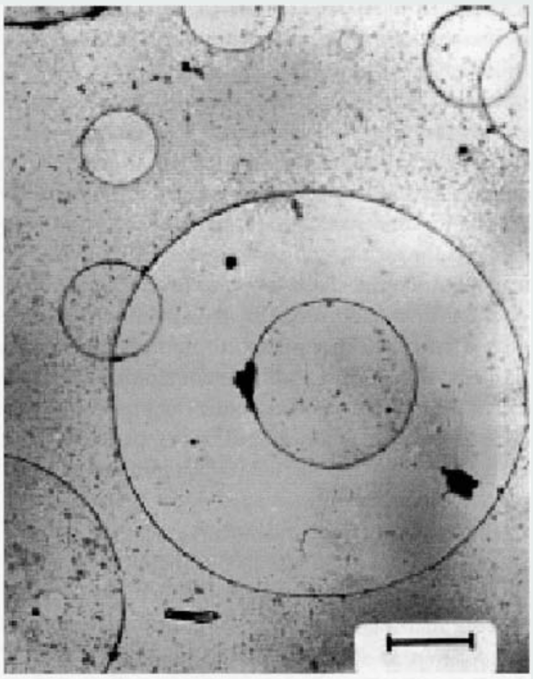
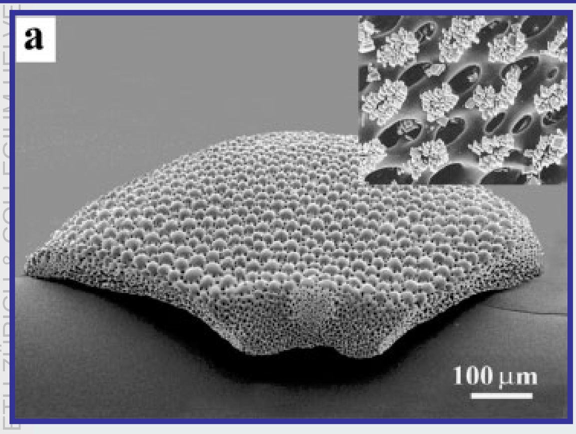


Fig. 6.4. TEM micrograph showing the self-organization of super-paramagnetic nanoparticles into submicron size rings the so-called *Olympic Rings* (scale bar is 0.7 µm).

Hierarchical Crystals from Biomin

Figure 1. Scanning electron micrographs of biogenic calcium carbonate structures: a) Dorsal arm plate of the brittle star *Ophiocoma wendti* with the external array of microlenses. The entire elaborate structure is a single calcite crystal. The lenses are oriented in the optic axis direction of the constituent birefringent calcite. Inset: Epitaxial overgrowth of synthetic calcite crystals on a brittlestar stereom. Note that the nucleation of the newly formed calcite



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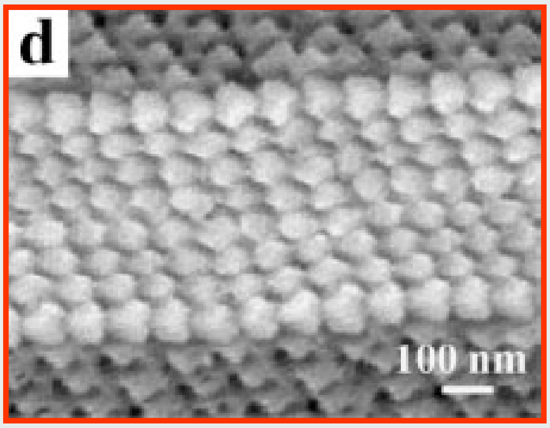
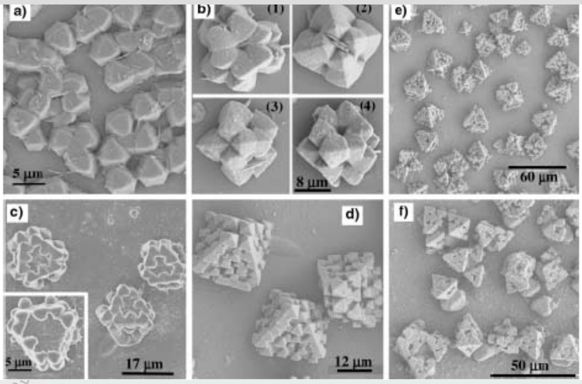


and macromolecules to the local sites of active growth (indicated by arrows). d) Fragment of a coccolith skeleton composed of a highly periodic array of oriented, uniform nanocrystals of calcite.

Super Crystals



hybrid mesoporous crystals using 1,2-bis(trimethoxy silyl) ethane (BTME) as a silica source and Hexadecyl-trimethylammonium chloride (CTAC) as a surfactant

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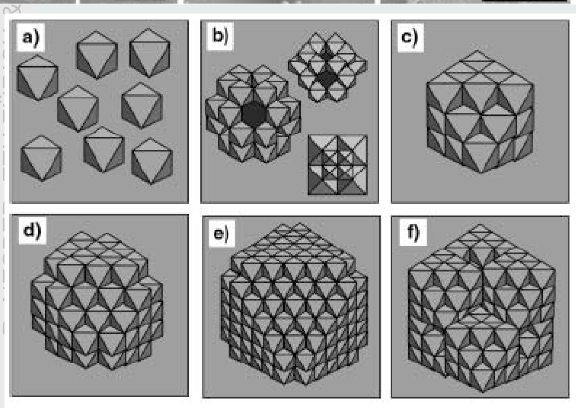


Schematic illustrations of edge-sharing stacking:
a) primary octahedral units, face-on configurations,
b) quartet-octahedron modelfor the secondary structure,
c) tertiary structure with filled corners,
d) tertiary structure with unfilled corners,
e) a high-order structure from primary octahedra,
f) a high-order structure from tertiary units.

Principal Forms of Hierarchical Organization

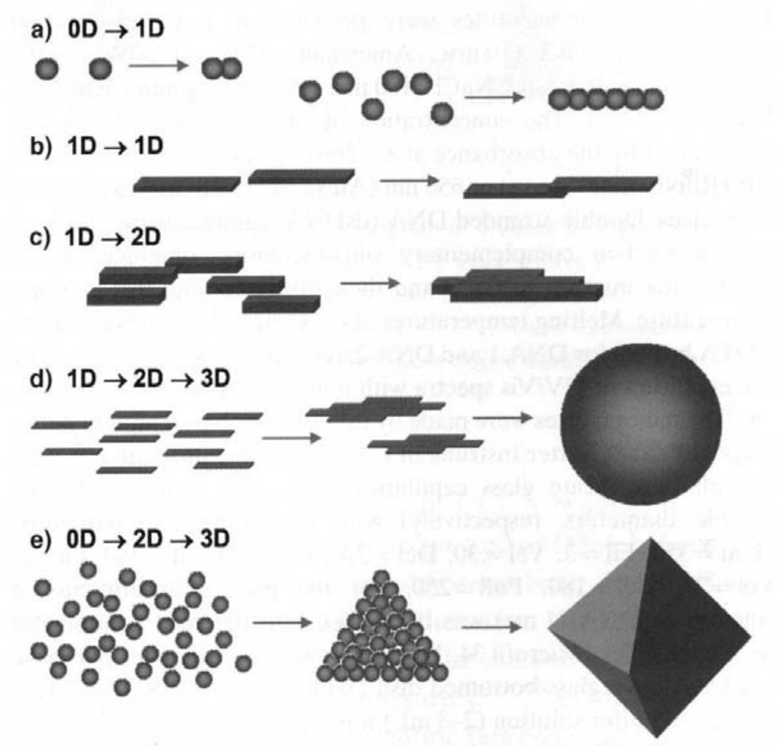


Figure 1. Various organizing schemes for self-construction of nano-structures by oriented attachment.

Metal Cluster Organizations

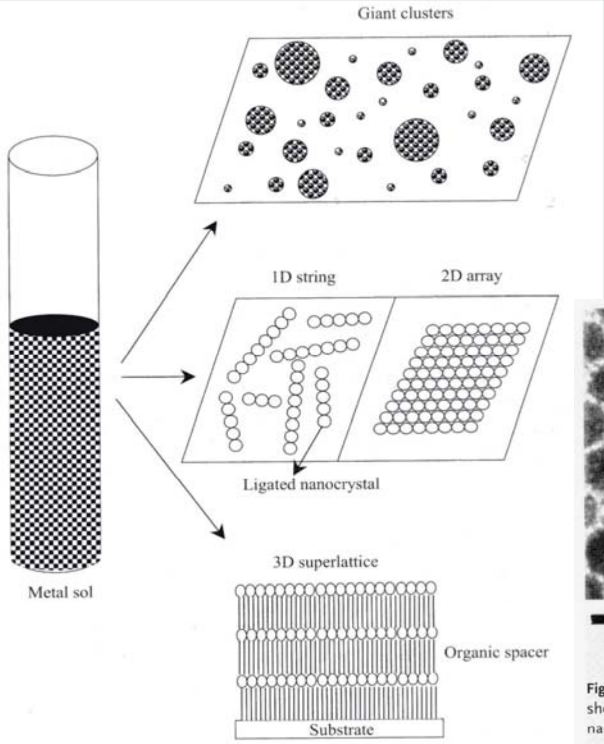
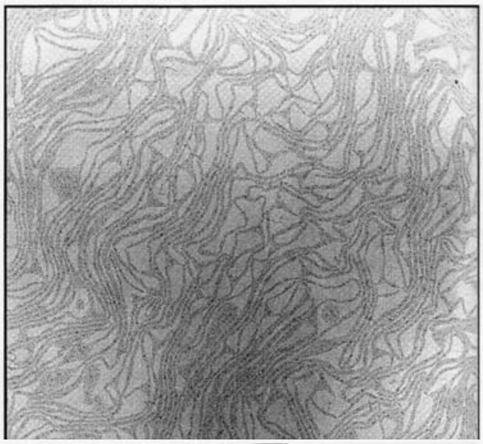


Fig. 4.8. Schematic illustration of the various metal nanocrystal organizations.



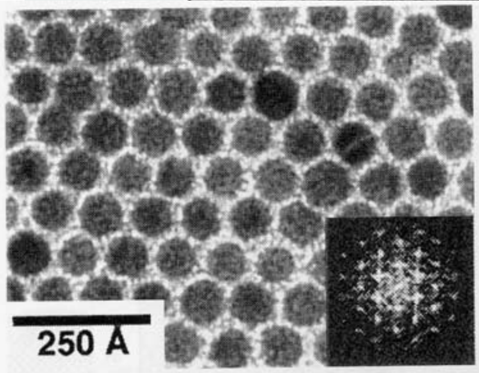


Fig. 4.10. Transmission electron micrograph showing hexagonal close-packed Ag nanocrystals (diameter, 7 nm) obtained by evaporating a chloroform dispersion on a carbon substrate. The average interparticle distance is 1.5 nm. Inset shows the 2D power spectrum of the image (reproduced with permission from [112]).

Metal Cluster Organizations

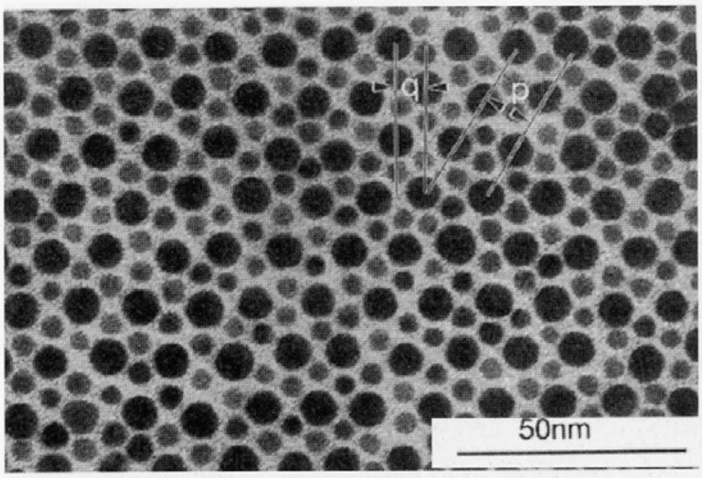


Fig. 4.14. A bimodal hexagonal array of Au nanocrystals. The radius ratio of the nanocrystals is 0.58 (reproduced with permission from [113]).

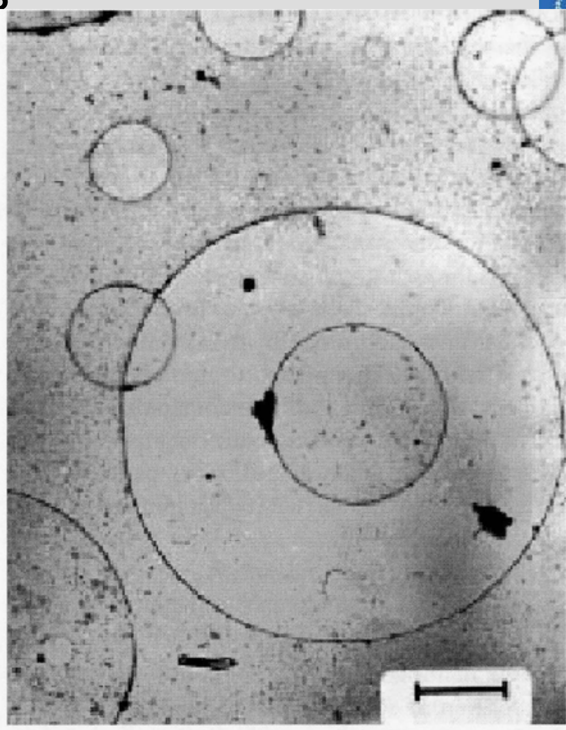


Fig. 6.4. TEM micrograph showing the self-organization of super-paramagnetic nanoparticles into submicron size rings the so-called *Olympic Rings* (scale bar is 0.7 μm).

Super Crystals

Spontaneous ordering of bimodal ensembles of nanoscopic gold clusters

C. J. Kiely*, J. Fink*†, M. Brust†, D. Bethell† & D. J. Schiffrin†

* *Materials Science and Engineering, Department of Engineering, The University of Liverpool, Liverpool L69 3BX, UK*

† *Department of Chemistry, The University of Liverpool, Liverpool L69 7ZD, UK*

Nature (1998) 396, 444

primary structure

after aging

phase separation

design – two cluster sizes

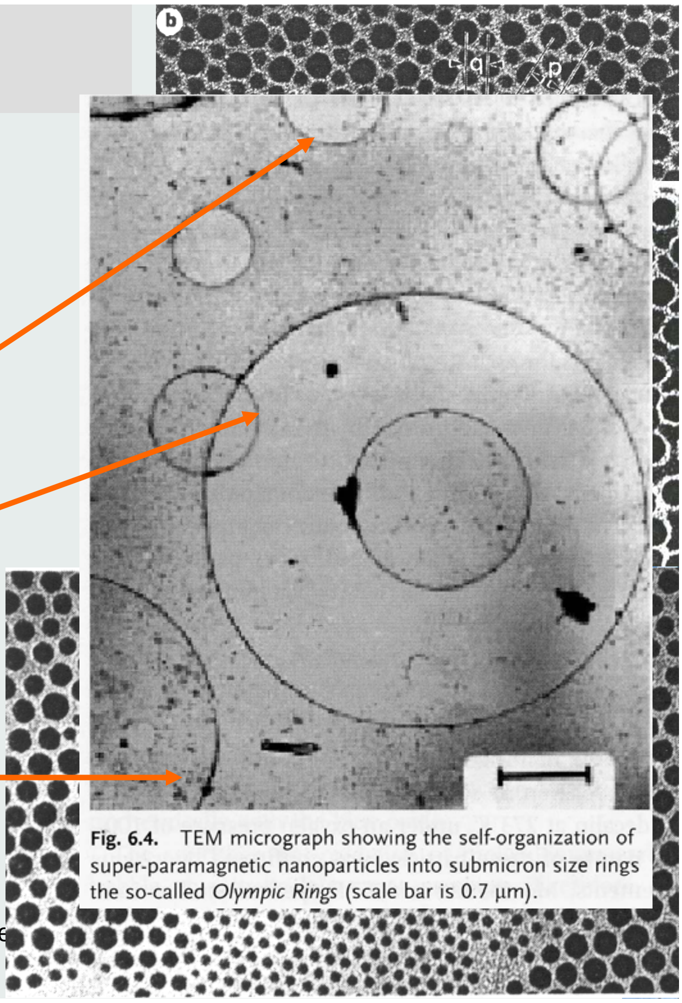
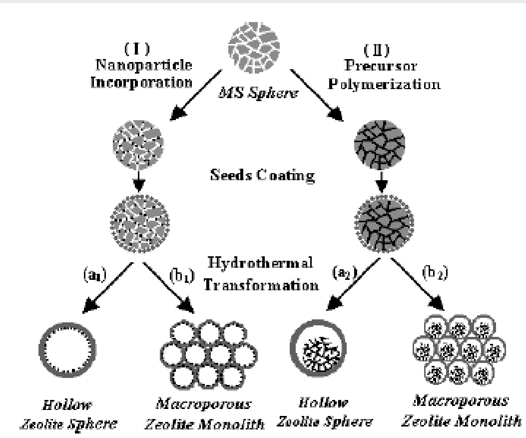
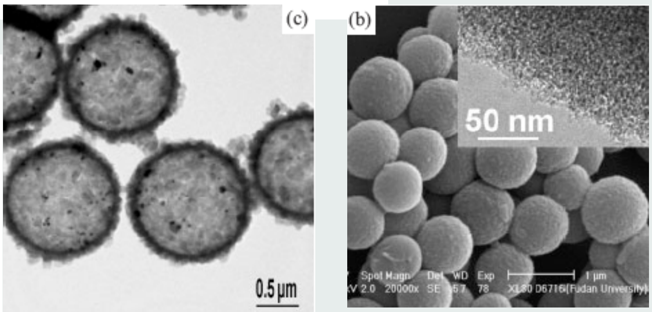


Fig. 6.4. TEM micrograph showing the self-organization of super-paramagnetic nanoparticles into submicron size rings the so-called *Olympic Rings* (scale bar is 0.7 μm).

Hierarchical Crystals from Zeolite Shells

Fig. 1. Schematic illustration for the encapsulation of nano- (I) and micrometer (II) sized particles into discrete hollow zeolite spheres (a_1,a_2) and macroporous zeolite monoliths (b_1,b_2).





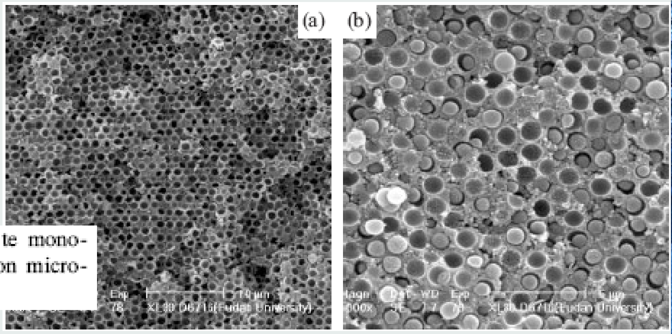


Fig. 7. Cross-sectional SEM images of macroporous zeolite monoliths encapsulated with PdO nanoparticles (a) and carbon microspheres (b).

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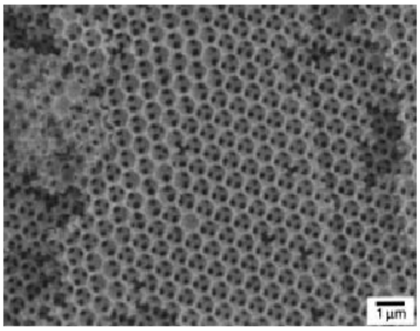
Selfaggregation and Micro Contact Printing



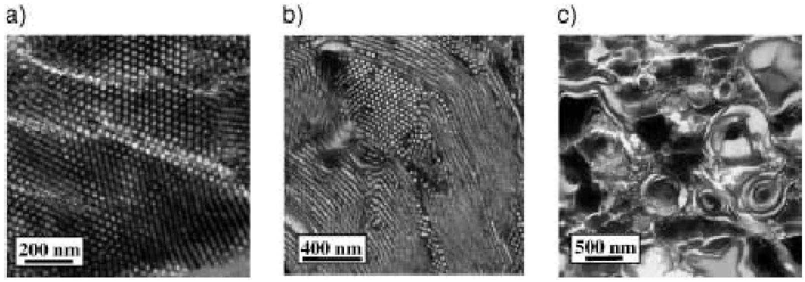


Abbildung 24. Silicate mit a) kubisch geordneten sphärischen Poren, b) hexagonal geordneten zylindrischen Poren und c) lamellaren Poren, hergestellt aus lyotropen Phasen von Blockcolymeren.[95, 134]

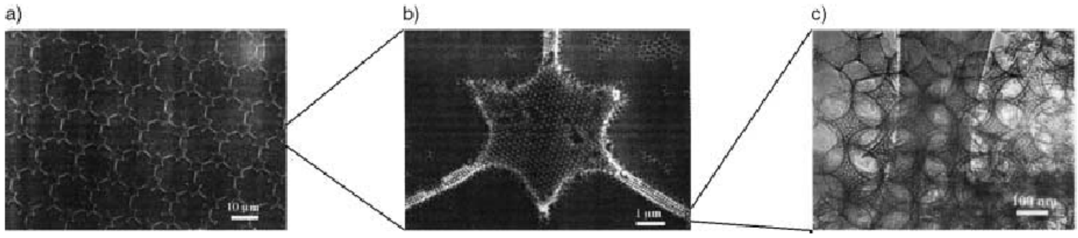
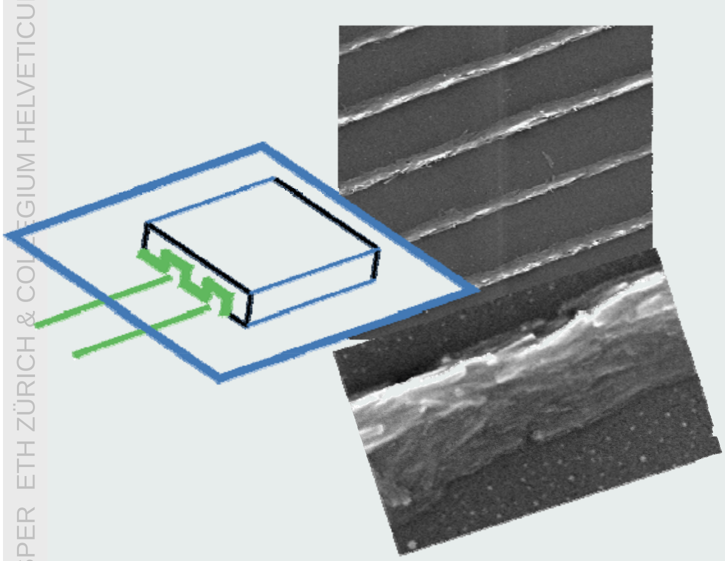
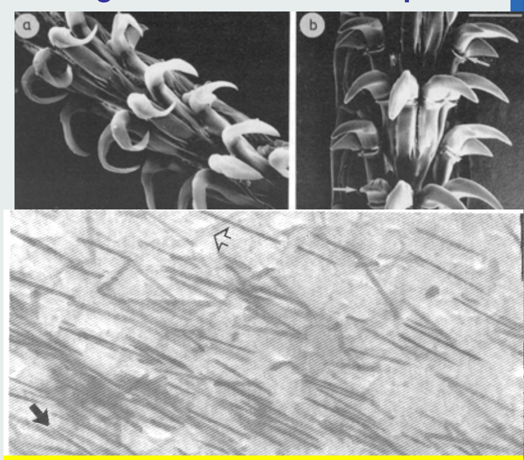


Abbildung 26. Elektronenmikroskopische Aufnahmen einer durch Mikrokontaktdrucken und Selbstanordnung hergestellten Strukturhierarchie über drei Organisationsebenen: a) Mikrokontaktmuster ($d = 15$ µm), b) makroporöse Struktur ($d = 200$ nm), c) mesoporöse Struktur ($d = 2$ nm).[150]

Alignment of Nanotubes and Nanorods



collagene + α–FeOOH composite



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