

Design of magnetic nanoparticles for photonic applications

- Photonic crystals based on colloids
- The colloids
 - Silica
 - Silica with magnetic core

Wim Libaers

Molecular and Nanomaterials

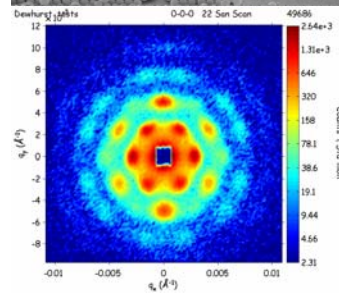
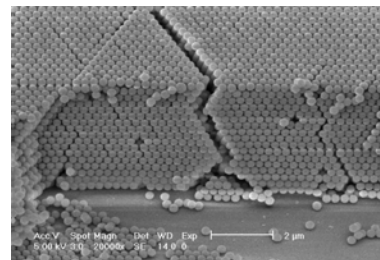


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Crystals from colloids

- A self-assembly method was used to form 3D photonic crystals from monodisperse colloids
- These crystals are fcc close packed and well ordered over long distances
- Long range ordering was confirmed from a neutron scattering image with a beam size of 7x10mm

(sample preparation in collaboration with Wim Vinckx, VSM. Small angle neutron scattering by Charles Dewhurst, Institut Laue-Langevin Grenoble)



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The colloids

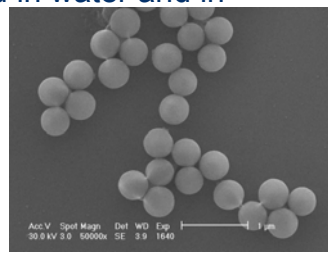
- Silica colloids were prepared using the Stöber synthesis



In ethanol, in presence of NH_3

(W. Stöber, A. Fink and E. Bohn, J. Colloid Interface Sci. 26 (1968), p. 62)

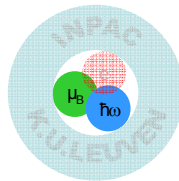
- These colloids are charged, stabilised in water and in alcohols by electrostatic interactions
- Isotropic and nonabsorbing particles



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Magnetic colloids with silica coating

- Magnetic particles (MP) are used for additional tailoring of optical properties of photonic crystals



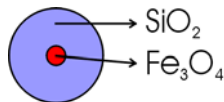
- Coating MPs with silica for size control and crystal preparation
- MPs with ionic stabilisation were used, covalently bonded stabiliser can block coating process



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Magnetic colloids with silica coating (2)

- A protocol from the literature (Adv. Funct. Mater. 2006, 16, 509) was adapted to create sizes useful for our purposes
- Magnetic cores: Fe_3O_4 prepared applying the Massart protocol (IEEE Trans. Magn, Vol. MAG-17 (1981), p. 1247), using ionic stabilisation by tetramethylammonium hydroxide



- The Stöber method was modified by using magnetic particles as seeds.
- The resulting hybrid silica particles were precipitated from suspension and dragged by using magnets, clearly demonstrating the inclusion of magnetic material.



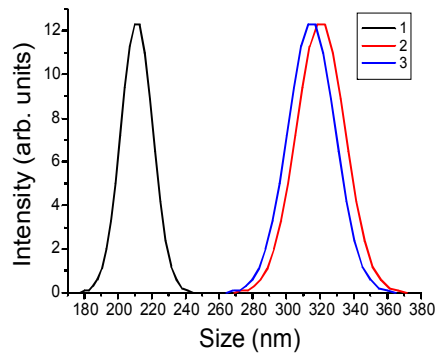
Characterisation of colloids

- Dynamic Light Scattering (DLS)
 - An estimate of the particle size distribution (as hydrodynamic radius) can be made from fluctuations in laser light intensity scattered from a suspension
 - Averages over a large number of particles
- Atomic Force Microscopy (AFM)
 - Imaging method
 - Gives direct information about individual particle sizes
 - Disadvantage: slow, therefore statistics about large numbers of particles are hard to get



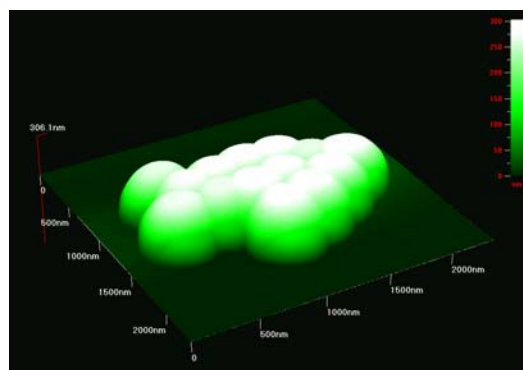
DLS results

- First magnetic silica particle hybrids: 210 nm (1)
- In order to get larger sizes, two approaches were used: (1) was introduced in suspension with additional silica precursors (2), or the previously described synthesis was modified with a higher amount of precursor (3).



AFM results

Clusters of particles were measured on silicon wafers, sizes are in good agreement with those obtained using DLS.

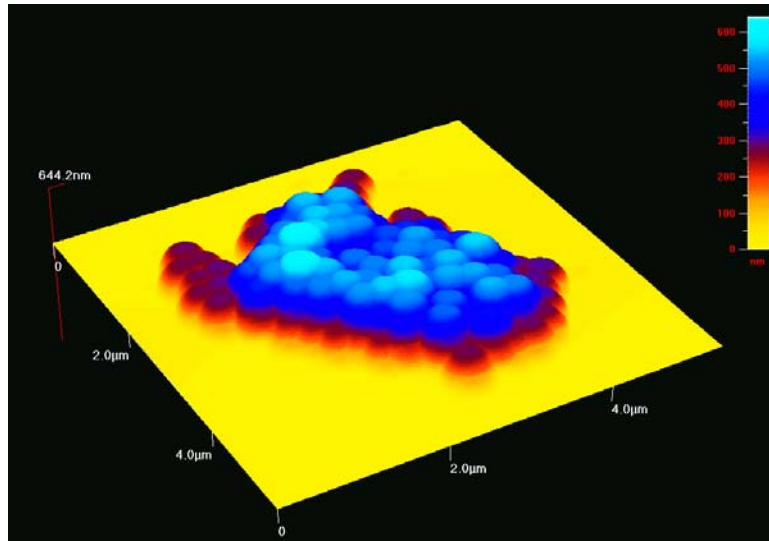


Cluster of particles,
height ~300 nm



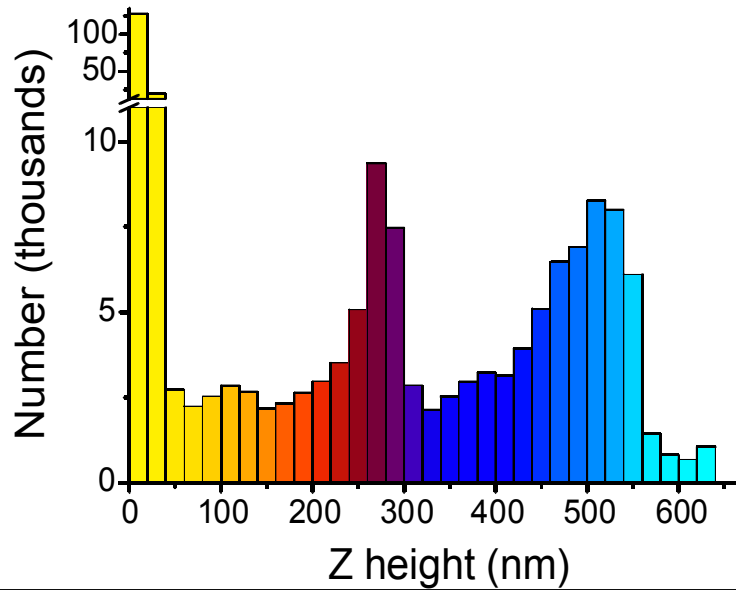
AFM results(2)

2 layer cluster, coloured to emphasize levels



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AFM: Z height histogram from previous image



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Outlook

- More complete characterization of these particles, including magnetic properties and SAXS
- Preparation of photonic crystals using these particles, to investigate the influence of magnetic fields on:
 - Photonic properties
 - Fluorescence in magnetic photonic crystals



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