Thermal degradation of magnetic $CoPt_3$ nanoparticles investigated by GISAXS

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Nano-scale magnetic structures offer a great potential for advancements in electronics, opto-electronics, high-density storage media, catalysis and biological applications. These nano-sized magnetic materials display properties that differ from their respective bulk material counterparts. High quality $CoPt_3$ nanoparticles were synthesized via simultaneous reduction of platinumacetylacetonate and thermal decomposition of cobalt carbonyl in the presence of hexadecylamine (HDA) and 1-adamantan carboxylic acid (ACA) as stabilizing agents [1]. The organic ligand shell around the magnetic $CoPt_3$ nanoparticles dictates the surface chemistry of the particles and has an influence on the solubility, the stability and the self-assembling of the particles on surfaces. Particles were dissolved in toluene and spin-coated onto silicon substrates. After deposition of the particles on the substrates, the particles self assemble into highly ordered 2-dimensional hexagonal arrays. The organic shell prevents the interparticle contact. To remove the organic ligands, the samples were heated to different temperatures for 2 hours. The stability of the particles and of the 2-dimensional arrangement is important for further applications, i.e. magnetic quantum dots. The characterisation of the obtained 2-dimensional nanoparticle-arrays surfaces has be done by scanning electron microscopy (SEM) and grazing incidence x-ray small angle scattering (GISAXS). For the GISAXS measurements we used the grazing incidence setup of the BW4 and the 2-dimensional CCD at a distance of 2.5 m (sample – detector). Accumulation time was 30 min at an incident angle of 0.6° and a wavelength of 0.138 nm. Figure 1 shows the schematic experimental geometry, described elsewhere in detail [2]. By analyzing the scattered intensity along a q_y cut by using our software "Scatter" [3], we were able to determine the lateral scales and the particle parameters of the structure, as presented in figure 2. At 300 °C the interparticle distance decreases, while the quality of the array is constant. At higher temperatures, the particles are starting to melt and form partial aggregates, which lead to a higher deviation of the particle form factor. Additionally the diffuse scattering increases and the order parameters show a stronger displacement of the particles from their ideal lattice points.

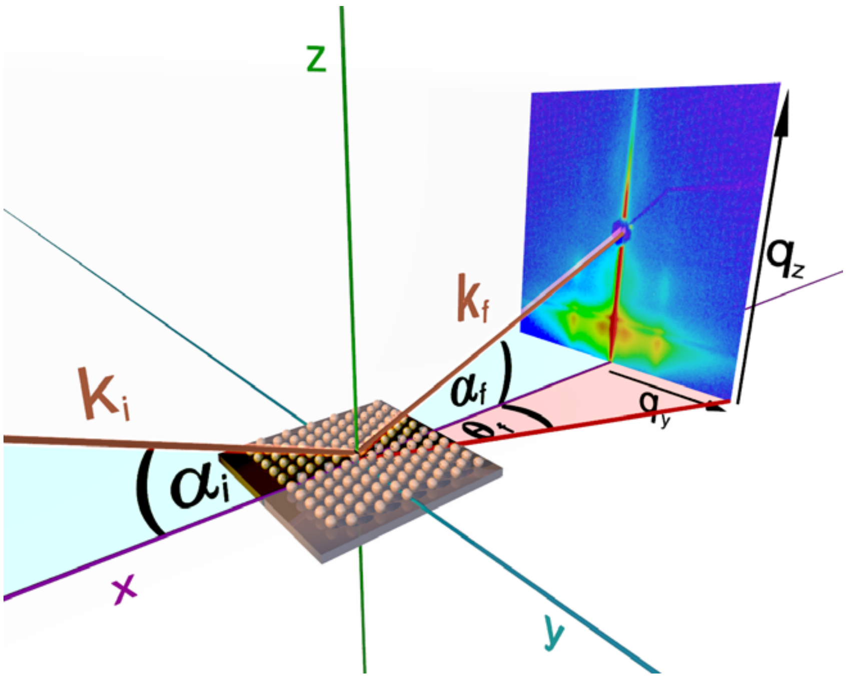

Figure 1: Schematic geometry of a GISAXS experiment [2]

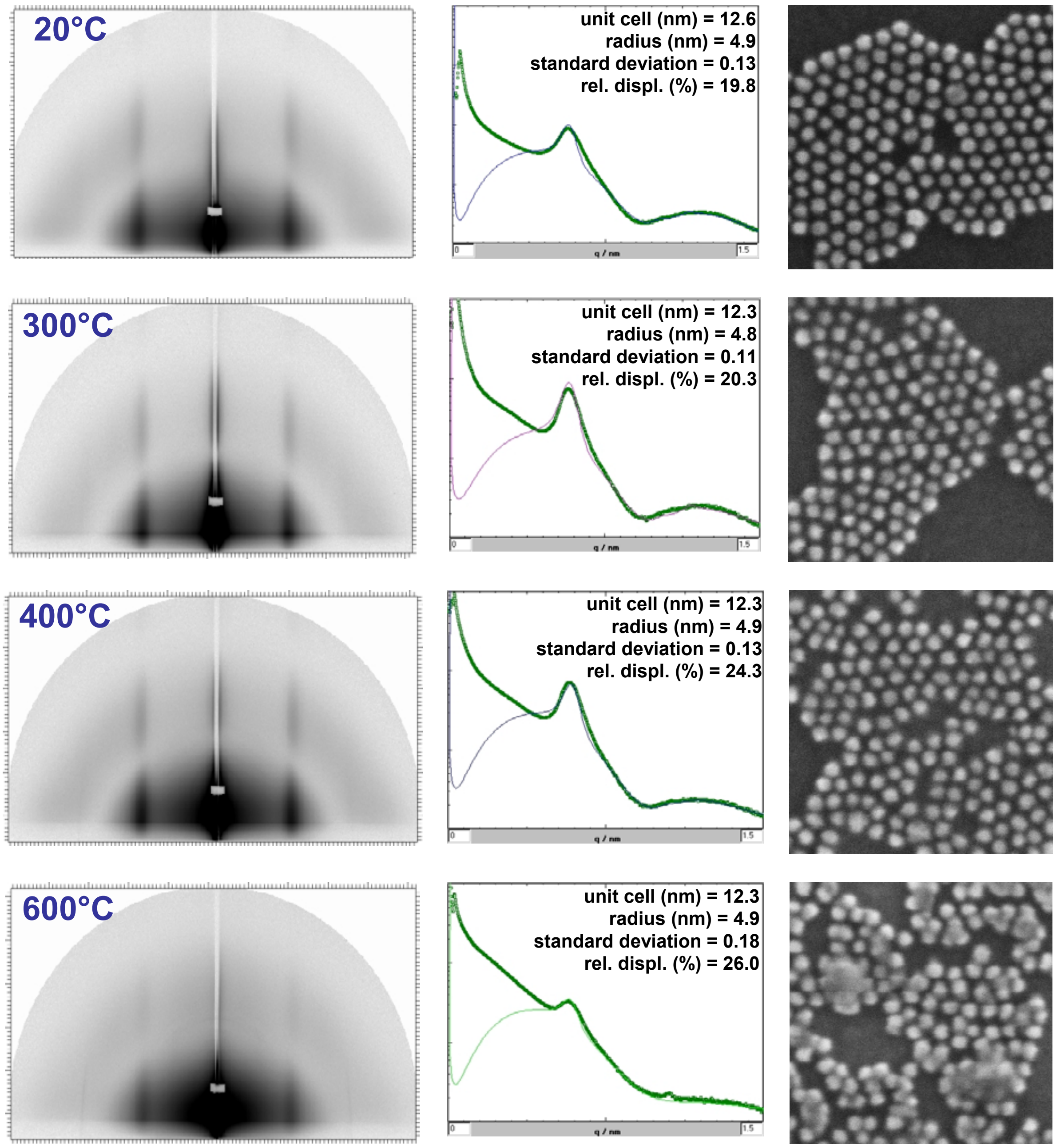

Figure 2: Thermal degradation of a 2D nanoparticle array at different temperatures – left: GISAXS patterns; mid: intensity profile cuts along q_y and *Scatter* simulation with parameters; right: SEM images (200 nm x 200 nm; 20 keV)

References

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