Self-assembly of magnetic nanoparticles on magnetically recorded templates with sub-100 nm feature sizes

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Using the enormous magnetic field gradients at the surface of recording media we demonstrate self-assembly of magnetic nanoparticles (MNPs) into crystalline patterns with feature sizes as small as 50 nm. Monodisperse 25 nm diameter particles colloidally suspended in hexane are assembled onto parallel line templates recorded into perpendicular recording media with varying line spacing [1]. Unlike assembly with aqueous polydisperse MNPs [2], here we observe hexagonal close packing of the MNPs where 200-300 nm spacings yield features that are 1-3 MNPs wide (Figure 1 a-b) while spacings 500 nm or larger yield features that are ~5 MNPs wide (Figure 1 c). For periods 300 nm and larger, distinct, separate parallel lines are created. However, for periods 200 nm and below, the parallel lines are joined or bridged together at locations where the MNPs protrude into the space between the lines. Destabilizing the colloid by adding a polar solvent such as ethanol reduces the crystallinity of the assembled MNPs at smaller periods, with patterns showing increased defects and larger edge roughness. For smaller periods ~ 50-100 nm, we observe linear chaining of the MNPs. Possible causes for the lack of separate lines at small periods include jitter in the x-position stability of the recording head during template writing, as well as the decreasing vertical size of the magnetic force as the lines approach one another. The transition to linear chaining suggests that changing spatial forces from the recorded transitions are competing with dipole-dipole interactions between the MNPs. Our results clearly demonstrate that controlling both the recording process and chemistry of the MNP solution are important factors for achieving patterns with high fidelity and single nanoparticle precision. In addition, the complex, spatially changing nature of the templating force must be accounted for to predict how MNPs will assemble on these templates.

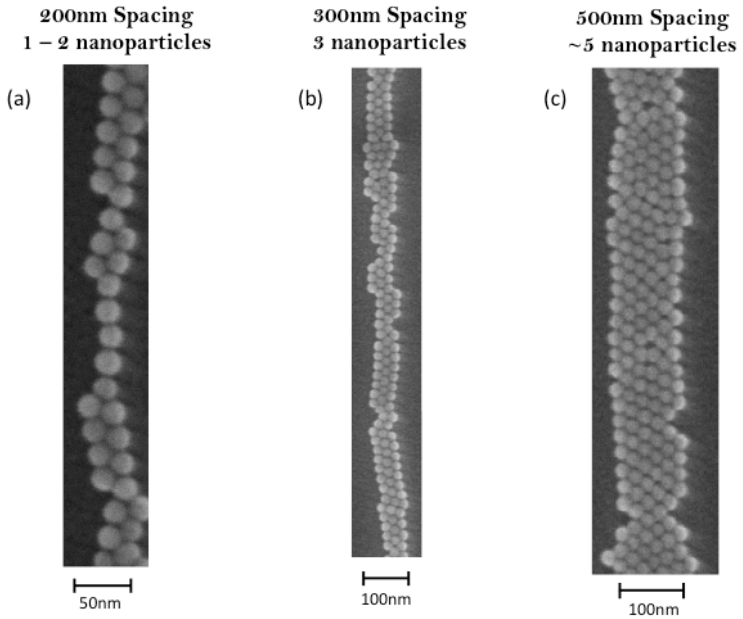

Figure 1 Scanning Electron Microscope images of magnetic nanoparticle self-assembly on magnetic recording media for different spacing

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