P.13 Design concepts for nanostructured colloidal composites

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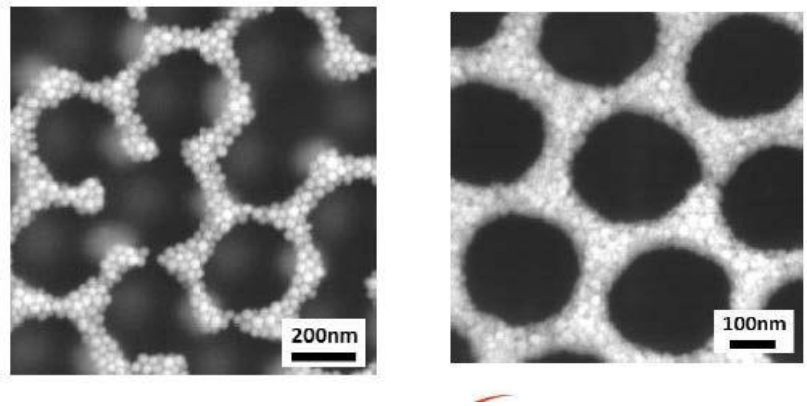
The assembly of colloidal nanoparticles into directed architectures is an emerging research theme that could enable the large-scale and low-cost fabrication of hierarchically structured nanomaterials, with applications in novel optoelectronic devices, sensors and metamaterials.[1-3] The self-assembly of nanoparticles can be employed as a low-cost approach compatible with large-scale device fabrication. However, the organization of plasmonic nanostructures over a large area (greater than several cm^2), achieved in a reliable self-assembly process, remains a grand challenge.[1,2]

Various types of fields (such as magnetic, electric or gravitational) can be used to guide and to direct the transport of colloidal particles. In this work, the transport of colloidal particles in water is directed in the vertical direction by variation of the balance between evaporation and diffusion. A Peclet number can be used to compare the rates of the two processes.[4] When diffusion is slow relative to evaporation (at a high Peclet number), particles accumulate near the top surface of a colloidal dispersion. In a binary blend of large and small particles, under the right conditions, large particles are predicted to be concentrated at the top surface. However, a simple geometric argument reveals that when the large:small size ratio is greater than about 7:1, the smaller particles can be transported through the interstitial voids between the larger particles.[5]

In this work, we use a combination of microscopies and Rutherford backscattering spectrometry (for elemental depth profiling) to map out the nanostructures that are created over a broad range of evaporation rates and particle size ratios in binary blends of nanoparticles. Gold nanoparticles (10 nm and 30 nm diameters) are blended with hard polymer particles with sizes ranging from 100 to 400 nm.[6] The evaporation rates are controlled by varying the water temperature (with infrared heating) and the relative humidity. The polymer particles sinter under IR radiative heating so that a hard nanocomposite coating results. We show that an understanding of the fundamental mechanism can be used to design various types of nano-ring structures, such as those shown here, along with more random structures, depending on the processing conditions and particle size ratios.



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