Ordered Structure Rearrangements in Heated Nanocrystal Superlattices

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Superlattices of gold and silicon nanocrystals were studied by small angle X-ray scattering (SAXS) as they were heated. Grazing incidence SAXS (GISAXS) data have revealed that superlattices of organic ligand-stabilized gold nanocrystals can undergo a surprising series of ordered structure transitions at elevated temperature. For example, a body-centered cubic (bcc) superlattice can evolve into a hexagonal close-packed (hcp) structure, followed by the formation of binary simple cubic (sc) AB13 and hexagonal (hex) AB5 superlattices. These transitions are driven by controlled nanocrystal growth during heating and the structures that form exhibit qualitative similarity with microphase-segregating diblock copolymers. Binary superlattices of larger silicon nanocrystals combined with smaller gold nanocrystals were also formed. When heated, the gold nanocrystals coalesce and segregate out of the the simple hexagonal (sh) AB2 binary superlattice to leave a simple hexagonal superlattice of silicon nanocrystals. This structure results from the high thermal stability of the silicon nanocrystals compared to the gold nanocrystals.