# Cooperative Assembly and Formation of Nanostructured Particle Arrays

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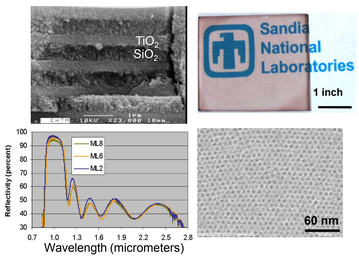
We developed a simple, scalable soft self-assembly process for the development of unique optical, electronic, and magnetic nanoparticle thin films at mild conditions, with architectures and properties unattainable by any other processing methods (CVD, sputtering, etc).




## Research Description

### 1. Motivation:

- To develop methods to synthesize nanoparticles (NPs) with robust surface chemistry and multifunction.
- To develop robust nanostructured NP arrays.
- To understand the collective electronic/photonic behavior of resulting NC nanostructures.

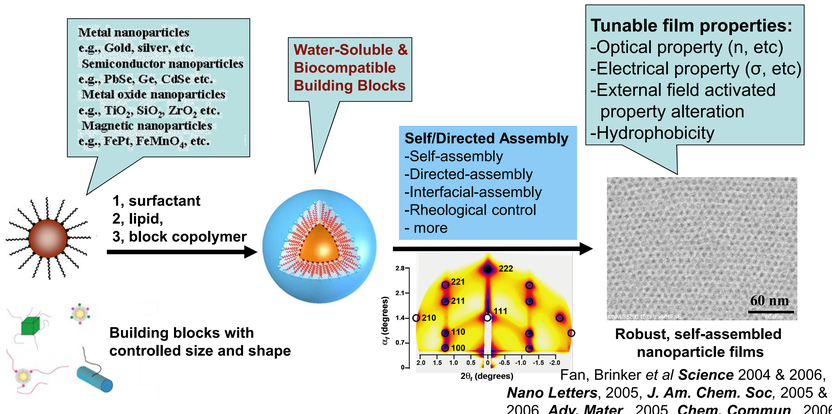
**2. Goal:** to develop new classes of well-defined 1 to 3D self-assembled model material systems in which to discover new nanoscale phenomena in order to provide the fundamental knowledge for aspects of current energy, water and climate challenges.

**3. Background:** Nanocrystals have important applications in catalysis, biolabeling, and microelectronics and optics. Ability to form monodisperse NPs with controlled shape, size, and surface chemistry, as well as films of ordered arrays are essential for their use in above areas.

### 4. Methods and Procedures:

**Soft Self-Assembly to Ordered Multifunctional Nanoparticle Films**

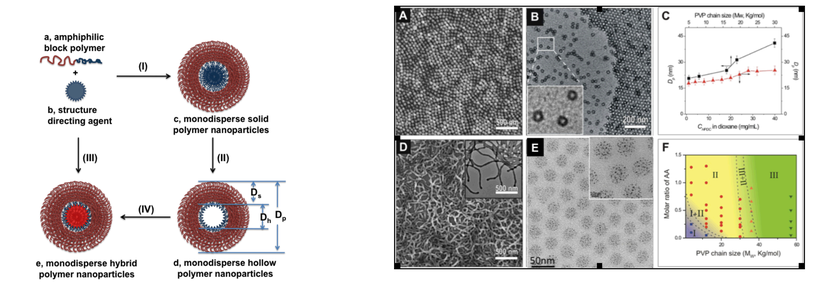
**(2007 R&D 100 Award & 2008 FLC Award)**




Fan, Brinker *et al* ***Science*** 2004 & 2006, ***Nano Letters***, 2005, ***J. Am. Chem. Soc***, 2005 & 2006, ***Adv. Mater.***, 2005, ***Chem. Commun***., 2006 & 2008, ***Adv Funct. Mater***., 2006, ***Chem. Mater.***, 2006.

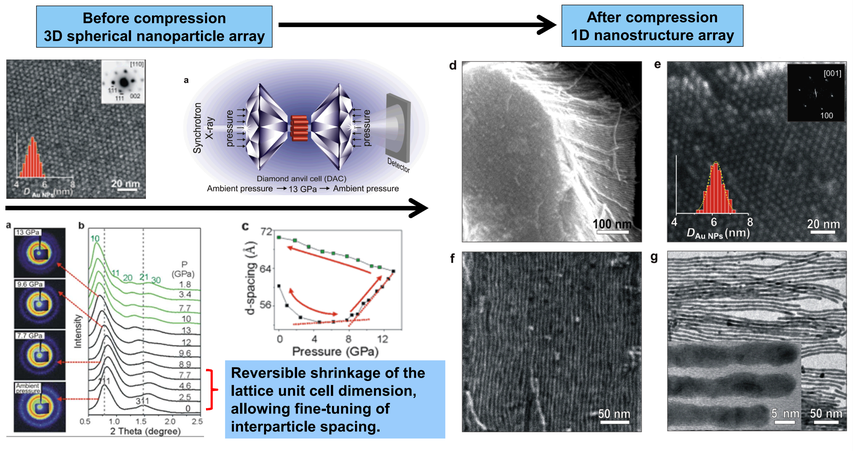
## Major Results & Impact

Cooperative non-covalent interactions, such as hydrogen bonding and aromatic π-π stacking, assist self-assembly of amphiphilic macromolecules and structure directing agents (SDAs) to form spherical and anisotropic polymer nanoparticles with tailored functions and properties.




Sun, Z. & Fan H. *et al., **J. Am. Chem. Soc.***,131 (38), pp 13594 – 13595, 2009; ***Chemistry - A European Journal***, 15, 11128 – 11133, 2009.

We demonstrate that an external hydrostatic field enables pressure modulated tuning of ordered nanoparticle arrays; an external uniaxial pressure field essentially overcomes balanced interparticle interactions to force nanoparticles to touch and sinter, forming new nanoparticle architectures.




## The Future

**5. Summary:** We developed an interfacial self-assembly process in combination of non-covalent interactions to synthesize monodisperse nanoparticles with controlled shape, tunable surface chemistry, and tailored functions for integration of high-reflective and anti reflective coatings. We demonstrated that an external field (pressure) can be used to engineer NP assembly and fabricate new NP nanostructured arrays. This mechanical compression process opens up a new pathway to the engineering and fabrication of nanoparticle architectures.

**5. Significance:** Our self-assembly approach represents a simple, generic means to create highly uniform NC arrays with well-behaved, essentially 'model' properties. These materials are ideal for the investigation of transport and collective phenomena as they allow single electron transport effects to be studied at considerably higher temperatures than previously reported.

### 6. Future work:

- Investigate pressure-induced assembly processes for fabrications of new nanostructures.
- Perform *in-situ* characterizations of nanostructures under different pressures using SAXS, SEM, TEM, optical absorption, etc. to understand the particle sintering process.
- Interrogate optical/electrical property associated with the new aymmetric arrays during compression.
- Build structure models to rationalize structural energy associated with nanostructure lattice transformation and to guide material design and synthesis.

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