# Core-Shell Nanocrystal Spring Magnets

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## Motivation:

Nano-scaled magnetic materials have tremendous potential for applications including:

- Stronger permanent magnets
- Multi terabit/in$^2$ data storage systems
- Ferrofluids
- Magnetic refrigeration systems
- Enhanced magnetic resonance imaging
- Catalysis
- Targeted drug delivery

## Current Challenges:

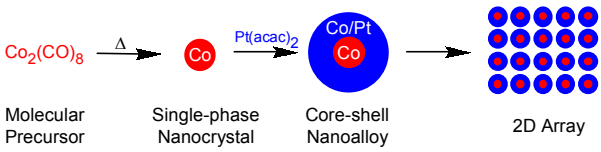
1) To overcome lithographic limitation.
2) To overcome superparamagnetic limitation.
3) To control the uniformity of media on the nanometer length scale.
4) To obtain unique magnetic properties on a single particle level.

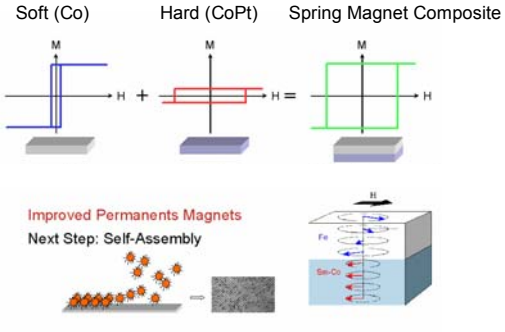
## Thrusts:

1) Precise chemical synthesis of nanoparticles.
2) Incorporation of particles into organized assemblies.
3) Control of electronic, optical and magnetic properties.

## Proposed Research:

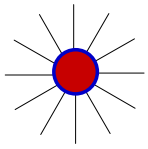
1) Synthesize monodisperse nanomagnets with well defined shape
2) Control the magnetic functionality on a single nanocrystal level by forming core shell spring magnets.
3) Form large assembly of nanocrystals.



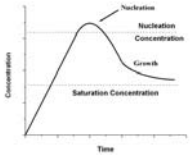




## Synthesis of Magnetic Nanoparticles:

1)Decomposition of metal carbonyl.
2)Chemical reduction of metal halide.



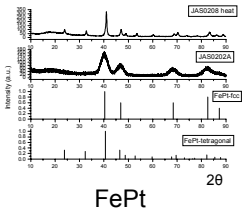
4 nm diameter FePt Core
0.4 nm $Fe_2O_3$ coating
Organic surfactant



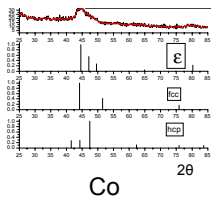

Monomer concentration change during nucleation and growth of nanocrystals.

## Characterization:

1) Powder x-ray diffraction.

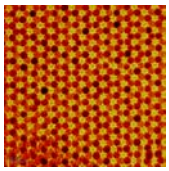



FePt

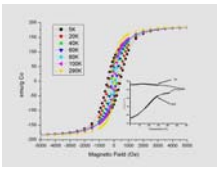



Co

2) TEM



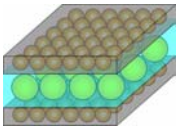
3) Magnetism



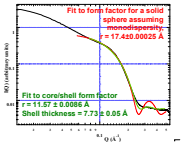
Highly monodisperse 9.6 nm ε-cobalt nanocrystals.

## Future Directions:

1) Organization in soft matter:

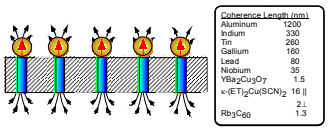


SAXS Profile on FePt nanoparticles

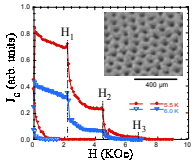



- Use complex fluids to organize magnetic nanoparticles.
- SAXS indicates that NP remain as discrete particles and do not agglomerate.

2) As vortex pinning sites:




Want pinning centers to be 2ξ apart.




### Goals:

- Enhance critical currents in superconductors.
- Study physics of nanoparticle / superconductor arrays.

**BES - DOE**

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**MSD - ANL**

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