

#### Novel Structures and Magnetism in Nanomagnets

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#### 1. Introduction

#### 2.Experiment

### 3. Conclusion





# **Cluster-deposition method**

<u>Objective</u>

To learn how the magnetic nanoparticles are made and characterized.



- Nanoparticle
- Narrow size-distribution

National Nanotechnology Coordinated Infrastructure

- High-density magnetic recording
- Spintronic devices
- Ultra-strong permanent magnets

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# **CoSi Skyrmion**



Magnetic skyrmion is a topologically stable particle-like spin configuration



(e) Skyrmion

Schematic representations of magnetic dipole arrangements in (a), (b), (c), (d), and (e)

Skyrmion  $\rightarrow$  the non-centrosymmetric B20 cubic structure, such as MnSi, and FeSi





Δ

### **CoSi conditioons**





# **TEM micrograph**



#### HRTEM image

Single crystalline particle High degree of atomic ordering



#### Low resolution TEM Image and particle size histogram

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### **SQUID measurement**



M<sub>saturation</sub> = 132 emu/cc, 55 emu/cc at 10K and 300K respectively

Ferromagnetic, Tc> 300 K







### Analysis1





#### HRTEM image of nanoparticle

Fast Fourier Transform of HRTEM image showing cubic B20 structure.



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# Analysis2



**Cubic B20 structure** 

a = 4.45 Å V = 88 Å<sup>3</sup> = 88  $\times$  10<sup>-24</sup> cm<sup>3</sup>

No of atoms = 4 Co + 4 Si

M<sub>s</sub> = 132 emu/cc, 55 emu/cc at 10K and 300K respectively (SQUID) 1 emu =  $10^{-3}$  J/T, 1  $\mu_{B}$  = 9.274 ×  $10^{-24}$ J/T In case of 10 K  $M_s = 132 \times 88 \times 10^{-24} \text{ emu /unit cell}$  $M_{c} = 132 \times 88 \times 10^{-24} \times 10^{-3} \text{ J/T}$  $M_s = (132 \times 88 \times 10^{-24} \times 10^{-3})/$  $9.27 \times 10^{-24} \mu_{\rm B}$  $M_s = 1.25 \mu_B / unit cell$ 

 $M_{s}$  = 1.25/4 = 0.31  $\mu_{B}/Co$  at 10 K  $M_{s}$  = 0.52/4 = 0.13  $\mu_{B}/Co$  at 300 K







- CoSi nanoparticles were fabricated using cluster-deposition method.
- ✓ TEM studies show that the CoSi nanoparticles exhibit an average size of 11.6 nm and form B20 cubic structure.
- ✓ Magnetic measurements show that the CoSi nanoparticles is ferromagnetic with a Curie temperature above 300K.







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# Thank You



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