

# NEBRASKA NANOSCALE FACILITY: NNF

## Annual Site Report: 2018

David J. Sellmyer,\* Christian Binek,‡ Jacob John,† Terese Janovec§

\*Director: NNF and NCMN

‡Associate Director: NNF

†Coordinator and Program Manager: NNF

§Education and Outreach Coordinator: NNF

Nebraska Center for Materials & Nanoscience  
University of Nebraska

NNCI 3<sup>rd</sup> Annual Conference  
University of Washington  
September 12-14, 2018

# Outline

- ❖ **Site Overview**
- ❖ **Research Focus Areas and Outcomes**
- ❖ **User Statistics**
- ❖ **New Facility Capabilities**
- ❖ **Research Highlights**
- ❖ **Education-Outreach Activities**
- ❖ **Network Activity**
- ❖ **Resource Allocation and New-Equipment Acquisition**

# NNF/NCMN Staff



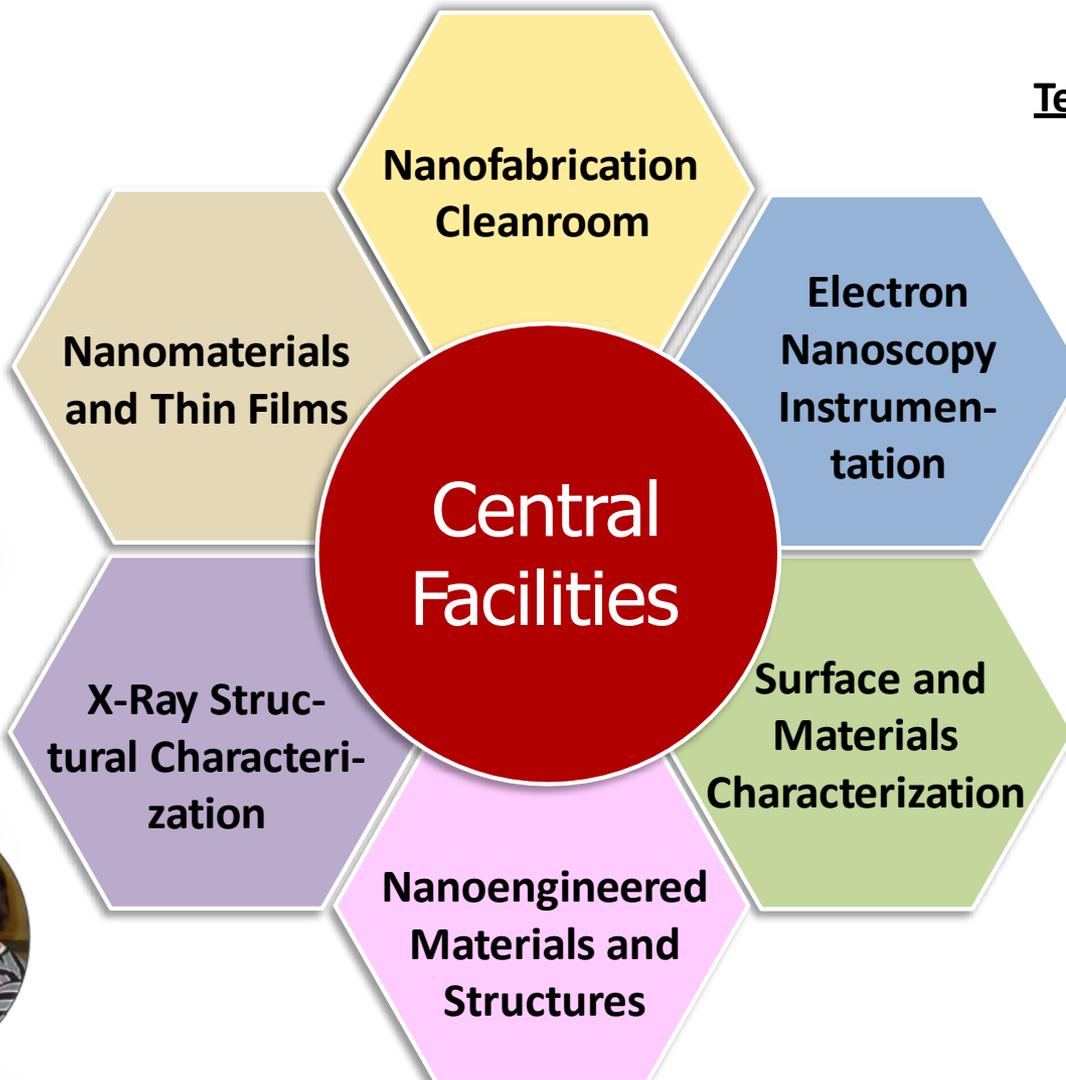
**Technical Staff: 10; Administrative Staff: 5**

# NNF Facilities

## Facility Staff



## Technical Outreach Staff



# Research Focus Areas



Evgeny Tsymbal



Michael Nastasi



Mathias Schubert



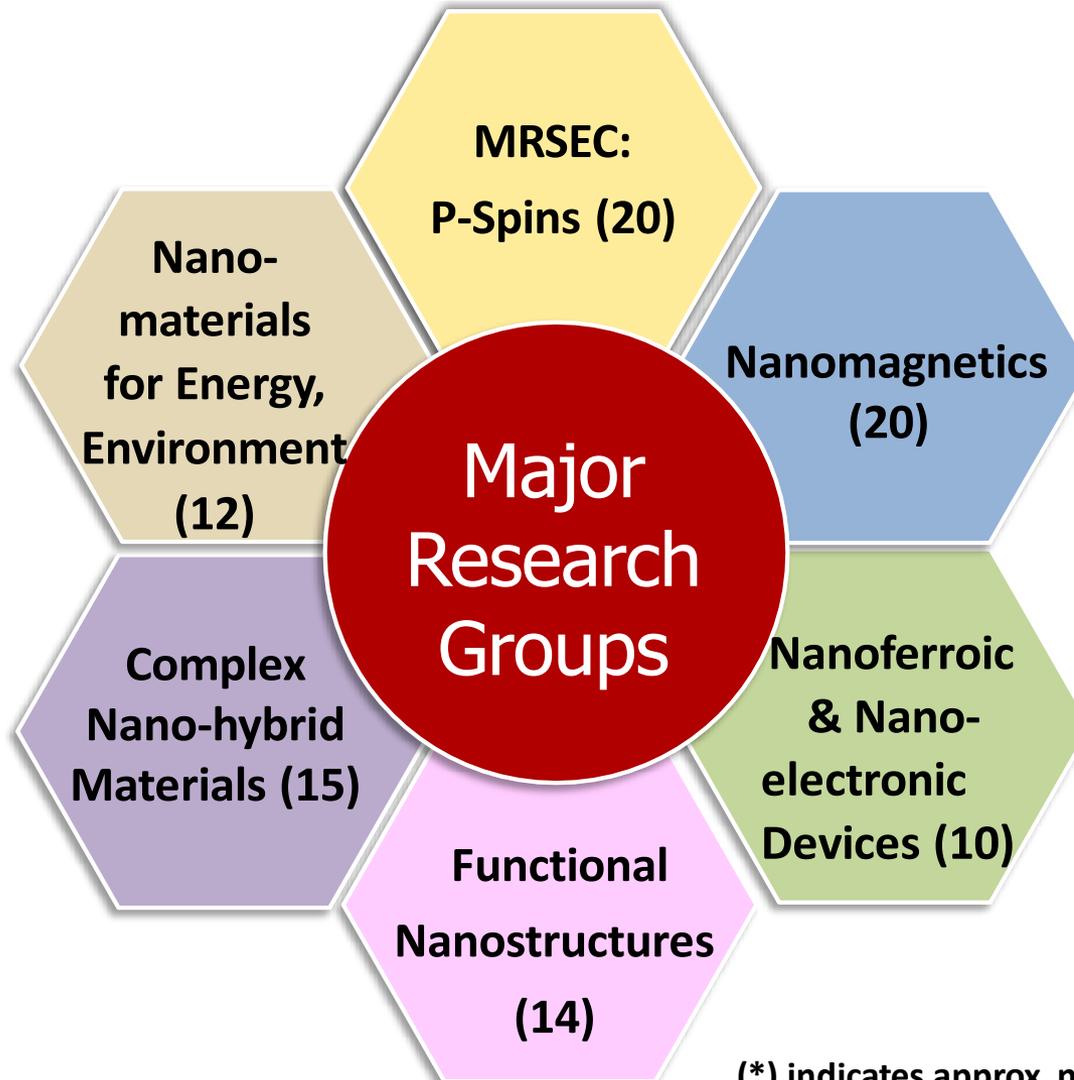
David Sellmyer



Christian Binek



Yongfeng Lu



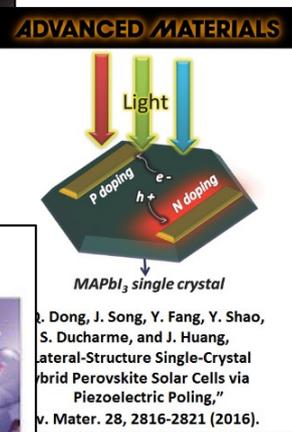
(\* indicates approx. number of faculty involved)

# High-Impact Research and Publications

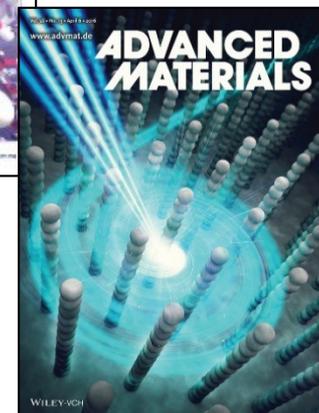
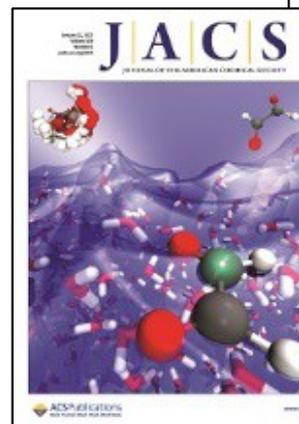


- Nature Photonics (1)
- Advanced Materials (6)
- ACS Nano (5)
- Science Advances (3)
- J. Am. Chem. Soc. (6)
- Nano Letters (8)
- Nature Commun. (6)
- Chem. Mater. (2)
- Phys. Rev. Lett. (3)
- Adv. Mat. Interfaces (12)
- Nanoscale (7)
- J. Mat. Chem. C (2)
- Acta Mat. (6)
- MRS Bulletin (4)
- J. Phys. Chem. C (5)
- Sci. Rep. (11)
- Phys. Rev. B (7)
- Appl. Phys. Lett. (18)

(2017)



... Dong, J. Song, Y. Fang, Y. Shao, S. Ducharme, and J. Huang, "Lateral-Structure Single-Crystal Hybrid Perovskite Solar Cells via Piezoelectric Poling," *Nature Mater.* 28, 2816-2821 (2016).



# Faculty Hiring Initiative

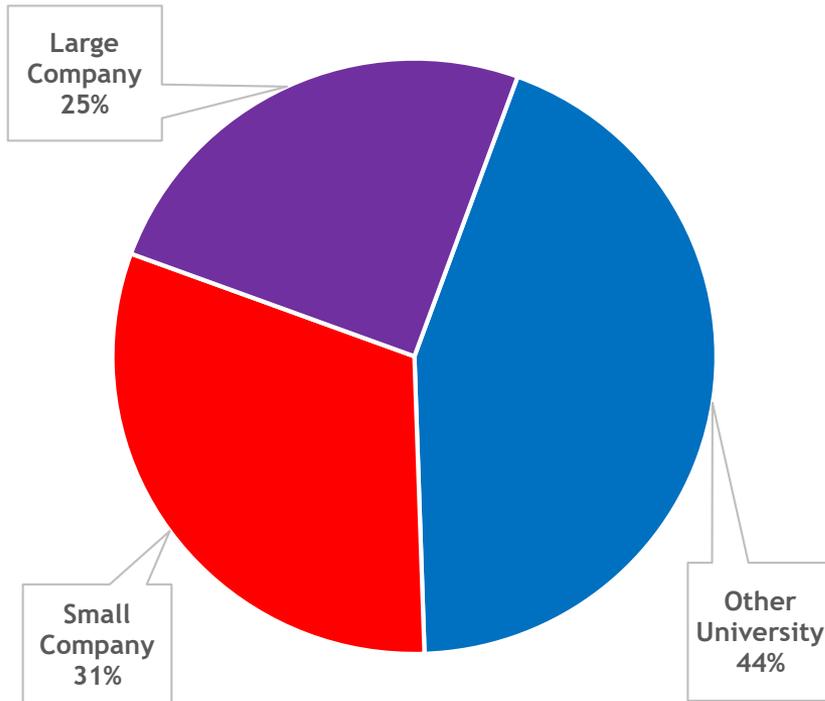
- ❖ NCMN has been planning for faculty development (~ 2 years)
- ❖ Talk on “Materials and Nanoscience” given to Board of Regents (2017)
- ❖ NNF External Advisory Board Review (2017) supported our hiring plan
- ❖ Many discussions with vice chancellors, deans, department chairs and faculty ⇒ Administration approved a set of 4 cluster hires in “Quantum Materials and Technologies”
  - ❖ [Physics, Materials, Chemistry, Electrical Eng.]
- ❖ Please let us know of excellent candidates!

# NNF: User Statistics

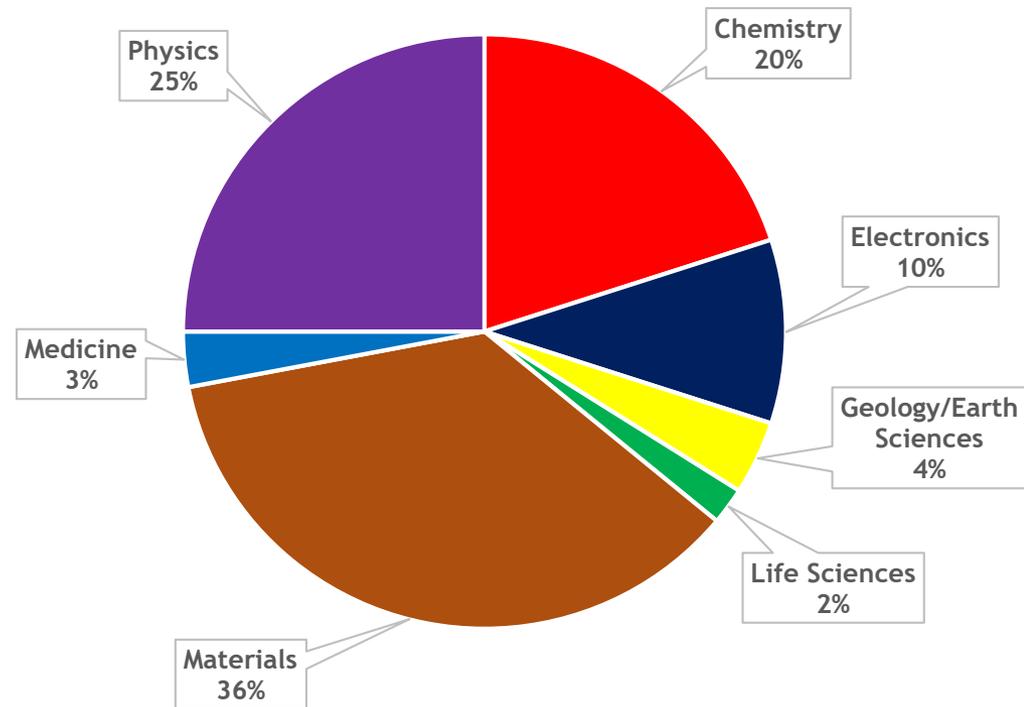
Yearly User Data Comparison			
	Year 1(12 months)	Year 2 ( 12months)	Year 3 (6 months)
<b>Total Users</b>	314	352	235
<b>Internal Users</b>	297	316	203
<b>External Users</b>	17 (5%)	36 (10.2%)	32 (14%)
<b>External Academic</b>	8	16	14
<b>External Industry</b>	9	20	18
<b>External Government</b>	0	0	0
<b>External Foreign</b>	0	0	0
<b>Total Hours</b>	23,446	20,102	12,307
<b>Internal Hours</b>	23,122	19,275	11,189
<b>External Hours</b>	324 (1%)	827 (4.1%)	1,118 (9%)
<b>Average Monthly Users</b>	97	120	132
<b>Average External Monthly Users</b>	1 (1%)	7 (6%)	12 (9%)
<b>New Users</b>	64	79	78
<b>New External Users</b>	6 (9%)	25 (32%)	27 (35%)

# NNF: User Data

## External User Affiliations



## All User Disciplines



# New Capabilities: Metal 3D Printers

Lumex Avance-25



LENS 3D Metal Hybrid System



- ❖ Hybrid Systems: Additive and subtractive (machining) capabilities
- ❖ Capable of printing reactive metals and composites

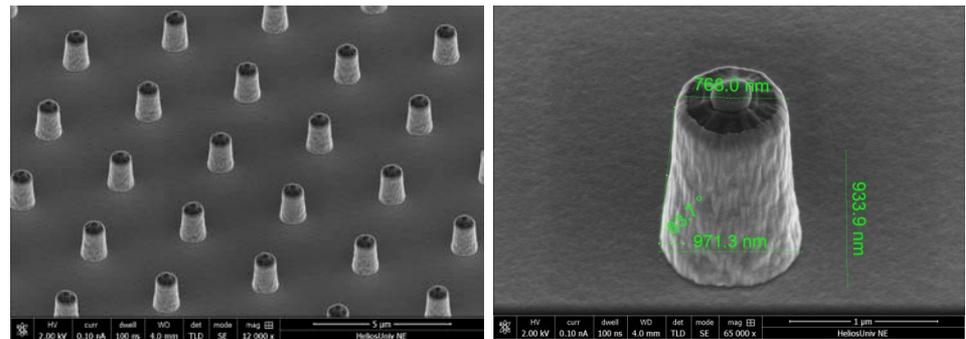
# Ion-Beam Etching and Sputtering System



Intlvac Nanoquest System

## Characteristics

- ❖ UHV chamber with base pressure of  $10^{-9}$  Torr
- ❖ One 14cm ion source for ion-beam milling
- ❖ One 4cm ion source for ion-beam sputtering
- ❖ 8 magnetron sputtering guns for complex thin-film stacks



Ti nano-pillars fabricated with Ion beam milling

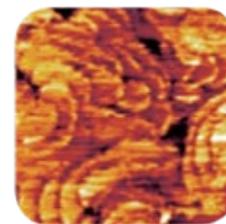
# Low-Temperature High-Magnetic-Field Scanning Probe Microscope (Attocube)



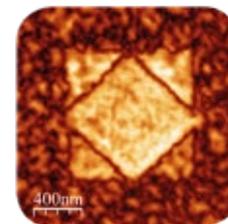
- ❖ NSF-MRI
- ❖ Temperature range: 4-300 K
- ❖ Magnetic field range: 0-9 T
- ❖ Multifunctional: AFM, MFM, PFM, ct-AFM



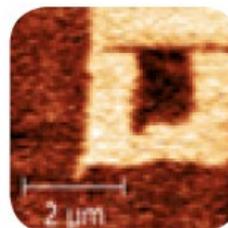
Surface Topography



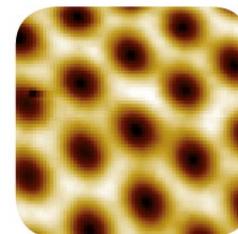
Conductivity Map



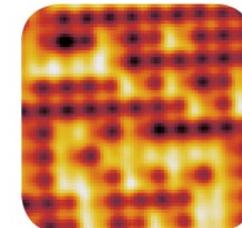
Ferroelectric Domains



Magnetic Nanostructures



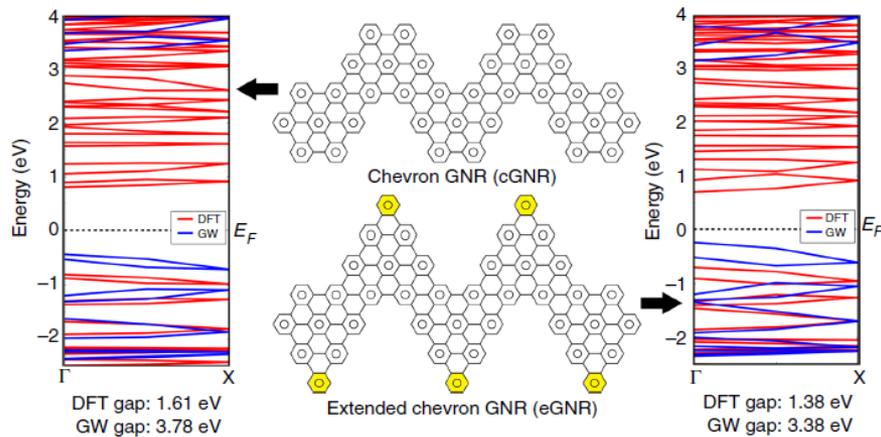
Magnetic Vortex



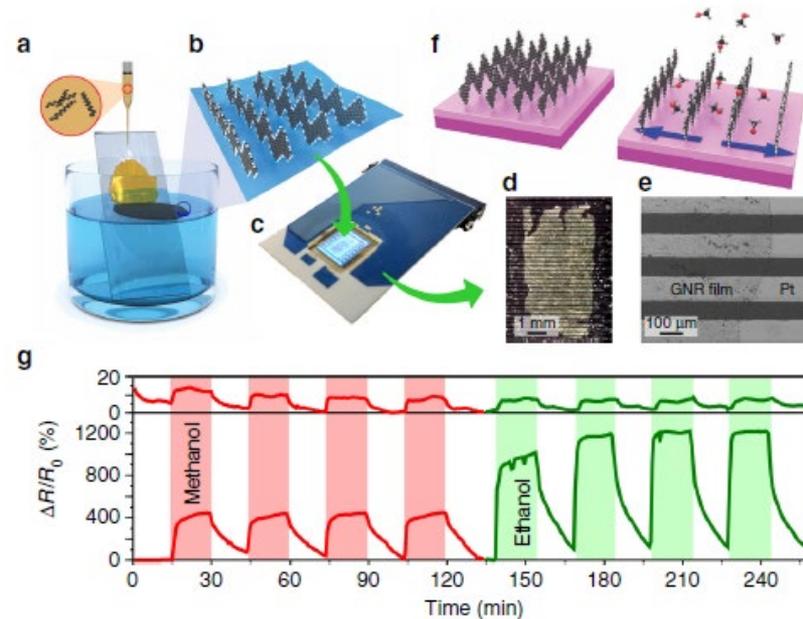
Magnetic Domains

# New Graphene Nano-ribbons Lead to Sensors with Unprecedented Sensitivity

- ❖ Sinitskii *et al.* have shown how to produce graphene nano-ribbons (GNR) by adding benzene rings, reducing its band gap and enhancing its electrical conductivity.



Effect of lateral extension on band gaps



GNR-based gas sensor

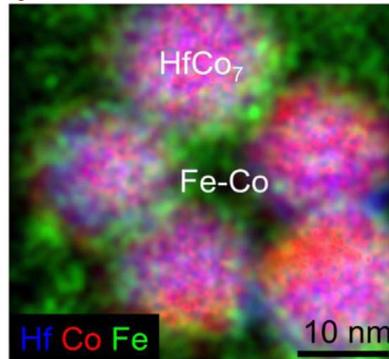
- ❖ This approach may be extended to sensing other molecules and photovoltaics.

*Sinitskii et al., Nature Commun. (2017)*

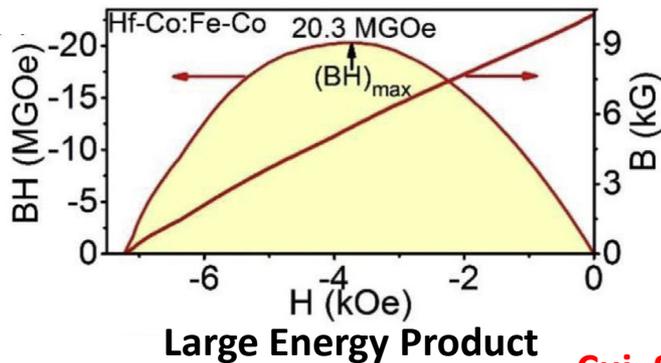
# New High-Energy-Product Nanomaterials

- ❖ New materials, especially earth-abundant ones, are needed for modern power-generation systems and vehicles.
- ❖ Combined experimental-computational research is leading to advanced metastable materials with potential for high-temperature use:

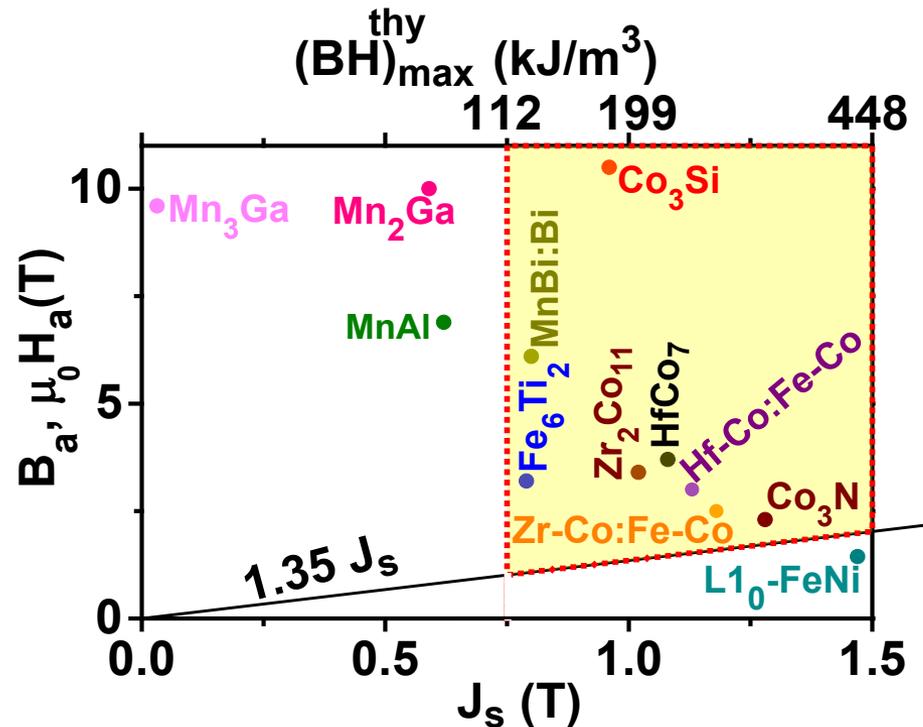
## HfCo<sub>7</sub>: Fe-Co Nanocomposite



HRTEM



## Potential High-Energy Product Materials



Cui, Sellmyer *et al.* *Acta Mat.* (2018), *Bull. APS* (2017)

# Impact of Education & Outreach Activities

NNF Sponsored Programs 2017-18	
Programs/Events	Participants
K-12 Students	310
Nanodays	400
Teacher Conferences	300
REU Students/Profs	9
Japanese NNCI REU (there)	1
Japanese NNCI REU (here)	1
High School Interns Summer Research	12
Preservice Teachers	13
Traveling Exhibit	52,000
Undergrad Women Conference	110
High School Women Conference	100
Nanotech Minicourse	20
Nanotech Workshop	30
Total NNF	53,306
Evaluated programs in blue	

## Traveling Nano Exhibit NNF Nanotech Workshop

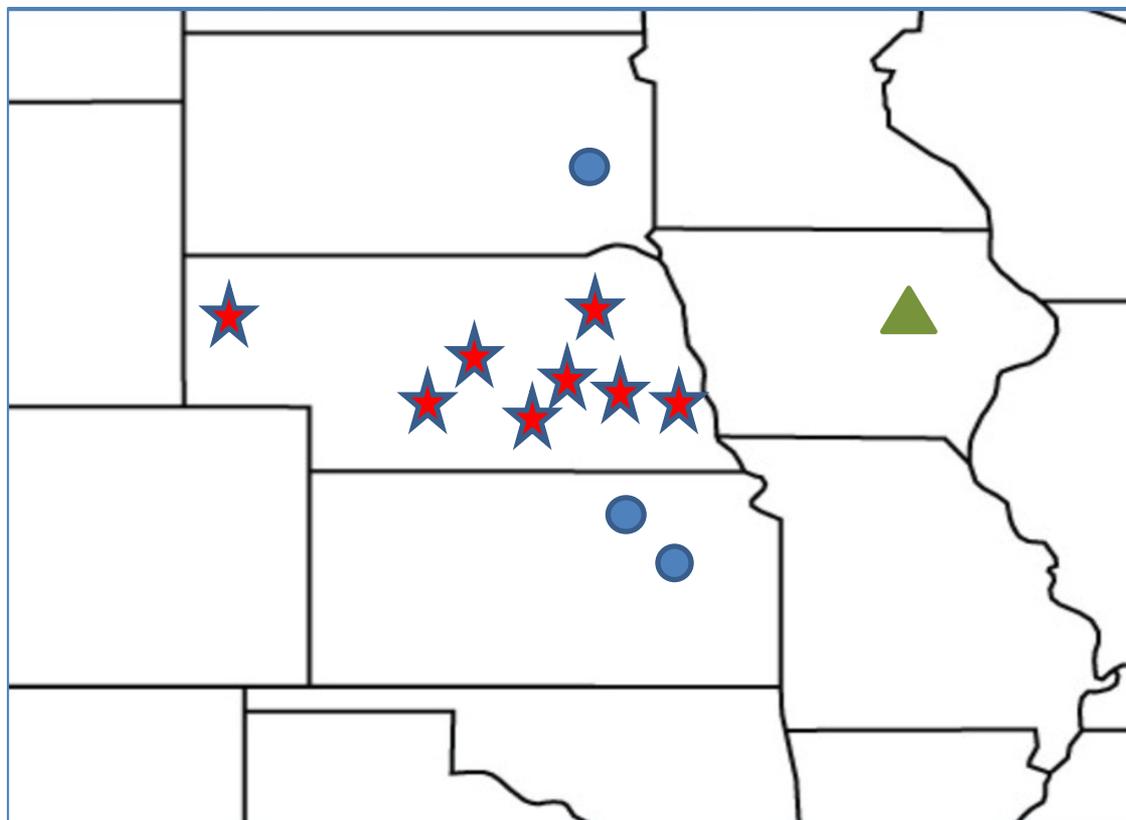


DIVERSITY EFFORTS	
Minority Serving Museums	
Chadron State College	50% Native American
Egerton Explorit Center	15% Hispanic 5% African American
Title 1 - After School Programs	
Dawes Middle School, Park Middle School, Goodrich Middle School	

Attendees (30)	Responses (18)			
	Strongly agree	Agree	Disagree	Strongly disagree
I understand what work can be done using NNF.	61%	39%		
I understand how to become a user of NNF.	67%	33%		
I believe my work would benefit from using NNF.	56%	34%	5%	5%
I am interested in using NNF.	50%	45%		5%

# Impact of Education & Outreach Activities

## Traveling Nanoscience Exhibit



Serving rural populations and growing communities of ethnic minorities

- ★ 8 museums in Nebraska
- ▲ Currently in Waterloo, IA
- Possible future visits in South Dakota and Kansas

# NNCI Cooperative Network Activities

## Network-Wide

- ❖ **NNCI Metrics Committee (David Sellmyer)**
- ❖ **NNCI Workforce Development Committee (Terese Janovec, David Sellmyer)**
  - Contributed to study of local CC needs/interests
- ❖ **K-12 Teachers/RET, Students, and Community Outreach Committee (Terese Janovec)**
- ❖ **NNCI Working Group Members (J. Hua, S. Valloppilly, L. Yue, J. Li, T. Janovec)**
- ❖ **NNCI 2017 Annual Conference (David Sellmyer, Christian Binek, Terese Janovec)**
- ❖ **NANODAYS 2018 in Lincoln hosted (Terese Janovec)**
- ❖ **RAIN Network (Anand Sarella, Terese Janovec)**

## Multi-Site

- ❖ **NNCI NSF RET Proposal (Jeff Shield, S. Ducharme)**
  - Six-week summer research experience (ASU, GA Tech, MN, Louisville, NE)
- ❖ **Lithography Workshop at Stanford (Jiong Hua)**

## On Behalf of the Network

- ❖ **NNCI REU student from Japan hosted, Summer 2018 (attended NNCI REU convocation)**
- ❖ **NNCI REU students (2) sent to Japan, Summer 2017 & 2018**

# Schemes for Funding New Equipment

- ❖ **Establish Revolving (Savings) Account**
  - **Difficult to achieve, but carry-over funds from operations help in equipment purchases.**
- ❖ **Matching Scheme**
  - **In requesting contributions from departments, colleges and vice chancellors, providing the *largest* amount from NCMN/NNF funds helps significantly in obtaining other contributions.**