Tomasz Durakiewicz
Program Director, Condensed Matter Physics Program

AVS64 Tampa, FL
October- November 2017
Materials Research Science & Engineering Centers (MRSEC)

- FY17 competition began EARLY.
- Pre-proposals received on **7/1/2016**. 75 pre-proposals (206 IRGs)
- Full proposals (by invitation) due **12/2/2016**. 18 full proposals (43 IRGs)
- Reverse Site Visit Invitations sent out **2/14/2017**. 10 with 26 IRGs
- RSVs start April-May, 2017
- **NEW**: Partnerships for Research and Education in Materials (PREM)

Solicitation 17-599 is out! Proposal Deadline: **January 29, 2018**
Results of recent MRSEC competition

Continuing MRSECs (5):

- Cornell, 3 IRGs
- UC Santa Barbara, 3 IRGs
- U Penn, 3 IRGs
- Northwestern, 2 IRGs
- Wisconsin, 2 IRGs

New MRSECs (3)

- U of Illinois, 2 IRGs
- UT Austin, 2 IRGs
- U of Washington, 2 IRGs
STC: CIQM
Center for Integrated Quantum Materials
Harvard, MIT and Howard
Director: Robert Westervelt

Mission

Transform electronics and photonics using 2D atomic layers, electron surface states and single-atom devices in Quantum Materials:

Atomic Layers: Graphene, BN, MoS$_2$ - ultrafast devices
Topological Insulators – topologically protect data
Nitrogen Vacancy Center Diamond – atomic memory

PO: Tomasz Durakiewicz
**Vision:** Transform imaging science and technology of functioning nano-systems

- **Advance** dynamic nano-imaging methods using electrons, X-rays and nano-probes
- Integrate these imaging methods to collectively provide new windows into functional nanosystems
- Collaborate to address important scientific and technological challenges

**Frederic Ives Medal / Quinn Prize**

Highest award of the Optical Society:

“for pioneering and sustained contributions to ultrafast science ranging from femtosecond lasers to soft x-ray high-harmonic generation to attosecond studies of atoms, molecules and surfaces.”
Designing Materials to Revolutionize & Engineer our Future (DMREF)

- Build the fundamental knowledge base needed to progress towards designing and making a material with a specific and desired function or property from first principles.
- Accelerate materials discovery and development.
- Collaborate and iterate “close the loop” between theory and experiment.
- Aspire to enable “data-driven” materials research.

![Graph showing funding in million dollars from 2012 to 2016 for various NSF programs: ACI, ENG-Other, ECCS, CBET, CMMI, MPS-Other, DMS, CHE, DMR. The funding rate is ~12%.]

Funding rate is ~12%.

John Schlueter
Susan Dexheimer

AVS, Tampa, Oct 2017
FY17 DMREF Solicitation Goes Biennial

NSF Solicitation 16-613

**Major Changes:** Biennial, Guidelines for Renewals, Target Areas

**Submission Window:** January 3-17, 2017

Awards are expected to range from $250,000 - $400,000 per year for a duration of 3 or 4 years, totaling $750,000 to $1,600,000.

Estimated number of awards: 20 - 25, depending on availability of funds

Total anticipated funds: $29.4 M

GOALI proposals may be submitted to the DMREF Solicitation
2D chalcogenide monolayers, surfaces and interfaces are emerging as a compelling class of systems with transformative new science that can be harnessed for novel device technologies in next-generation electronics.

**Focus:** 2-dimensional chalcogenide materials for future electronics

e.g., Can theory model growth kinetics and guide materials synthesis?

Find the 2DCC at www.mip.psu.edu

---

Fundamental growth processes of 2D systems

- Conformal and uniform coverage
- Large area growth

**Director:** Joan Redwing

**AVS, Tampa, Oct 2017**
Focus: interfacial materials, combining oxides & 2D materials, for valleytronics & spintronics

e.g., Can we design and create new interfacial materials by "breaking" Gibbs’ & Pauling’s rules?

www.paradim.org
Topical Materials Research Programs

Biomaterials

**Ceramics** FY17 (51 proposals), previous 3-yr. ave. (147)

Electronic & Photonic Materials

Metals and Metallic Nanostructures

Polymers

**Condensed Matter & Materials Theory** FY17 (202), previous 3-yr. ave. (287)

(Computational & Data-Driven Materials Research)

Condensed Matter Physics

Solid State and Materials Chemistry

**FY2017 Solicitations**

- for “open” unsolicited proposals windows

**Submission constraints**
- 3 strikes and “out” on resubmissions.
- Reduce multiple submissions in DMR.
- CMMT includes CDMR, with more emphasis on programs working together.
- Encouraging the best ideas rather than all the “reviewable ones”.

AVS, Tampa, Oct 2017
Division of Materials Research: Topical Materials Research Programs (DMR-TMRP)

NEW THIS YEAR: PROGRAM SOLICITATION NSF 17-580

Biomaterials (BMAT), Condensed Matter Physics (CMP), Electronic and Photonic Materials (EPM), Metals and Metallic Nanostructures (MMN), Polymers (POL), and Solid-State and Materials Chemistry (SSMC)

It does not apply to the following two DMR Topical Materials Research Programs, which have their own solicitations:

Ceramics (CER) (NSF 16-597) and
Condensed Matter and Materials Theory (CMMT) (NSF 16-596).
National Facilities and Instrumentation (NaFI):
National High Magnetic Field Laboratory

- Renewal proposal received in June 2016.
- Site-visit review in October 2016.
- **Quantum Materials** and **Magnet Development** major science drivers influenced by user community and NAS study.
- High Priority, but budget cuts will impede sufficient investment.
- **2022 MREFC opportunity**; threshold lowered to $70M. Workshop being planned – need for ultra-high magnetic fields for a “quantum leap”. (Led by Phuan Ong/Princeton for Fall 2017).
- **France Córdova visited MagLab recently**
Focus on research and education projects investigating the *fundamental physics* behind phenomena exhibited by condensed matter systems.
soft materials
quantum fluids
nano
granular
colloids
jamming
jamming
liquid and solid He
quantum
information
convection
turbulence
......
superconductivity
magnetism
heavy fermions
correlations
symmetry
topological phases
quasiparticles
degrees of freedom
interactions
ground states
phase transitions
......
Strategic Research Directions
NSF’s Big Ideas

Proposals that align with NSF’s Big Ideas are encouraged, but not required.

Harnessing Data

Shaping the New Human Technology Frontier

Quantum Leap

Understanding the Rules of Life

Navigating the New Arctic

Windows on the Universe

AVS, Tampa, Oct 2017
QUANTUM LEAP
Leading the Next Quantum Revolution

One of 10 Big Ideas announced by NSF in March 2016:
A plan to build on the First Quantum Revolution in early 20th century and prepare for the Second one exploiting quantum phenomena like superposition, entanglement, and squeezing to enable the next wave of precision sensors and more efficient computation and simulation and communication.

EU, Netherlands, UK, China, Japan, Canada... investing in development of quantum technologies.

NSF would support research that addresses the manipulation of quantum states and the control of material light interactions involving physicists, mathematicians, and engineers. There will be strong connections to industry, other federal agencies, and international partnerships.
Quantum Leap Strategies:

- **Beyond Core** – Development of programs for high-risk/high-payoff interdisciplinary projects that promote convergence.

- **Transformative Midscale Projects and Infrastructures** – Empower U.S. researchers to significantly advance the Quantum Leap.

- **Strategic Partnership** - Promote strategic mutually productive partnerships among academia, the private sector, other U.S. Government agencies and National Labs, and international researchers and organization.

- **Mentored Workforce** - Develop programs that grow, educate and train, and retain a new generation of well-mentored workforce.
QUANTUM LEAP FY17
NSF/DOE Quantum Science Summer School

Sources of funding
- NSF: $700k
- DOE/BES: $300k

Organizing Team
- Joe Checkelsky (MIT)
- Natalia Drichko (JHU)
- Liang Fu (MIT)
- Kyle Shen (Cornell)
- Jun Zhu (Penn State)

Organizing Team

Locations and Dates
- Tentative Location and Dates
  - JHU: June 5-16, 2017
  - Cornell: June 18-30, 2018
  - Penn State: June 9-21, 2019
  - University of Colorado: 2020

Rationale
- Train transdisciplinary workforce for the second quantum revolution driven by convergence of multiple disciplines

Participants
- 50 Graduate Students and early-career Postdocs
**Goal:** To challenge researchers to propose transformative research leading to the successful experimental demonstration of a topological qubit based on braiding anyon world lines or other known or creative new mechanisms enabling viable topological quantum computing.

**Mode:** whitepaper leading to EAGER proposal

**Level of support:** up to 300k$ over 2 years

**Key contacts:**
- CMP: Tomasz Durakiewicz, tdurakie@nsf.gov
- CMMT: Daryl Hess, dhess@nsf.gov
- EPM: Miriam Deutsch, mdeutsch@nsf.gov

**Announced:** Feb 6, 2017

Example of proposed experiment to demonstrate Majorana “fusion” – A key ingredient for fault-tolerant quantum computations; D. Aasen et al., Phys. Rev. X 6, 031016 (2016)

Shown: sets of semiconducting wires coated with a superconducting island and bulk superconductor that are bridged by a gate-tunable “valves.”
Funded EAGER:BRAIDING projects, 2 yr/$300k each

- Parity control and braiding of Majorana fermions in S-TI-S Josephson junction networks: 1745304; Smitha Vishveshwara; Dale Van Harlingen; University of Illinois at Urbana-Champaign
- **Majorana Bound States in Semiconductor Nanowire Networks**, Award Number: 1743972; Sergey Frolov; University of Pittsburgh
- **Collaborative Research: Manipulation of Majorana Modes in Topological Crystalline Insulator Nanowires**: 1743896 and 1743913; Judy Cha; Yale University and James Williams; University of Maryland College Park
- **Braiding Majorana bound states in atomic chains on a superconducting island**: 1744011; Stevan Nadj-Perge; California Institute of Technology
- **Braiding of Majorana Zero Modes in the Quantum Hall - Superconductor Hybrids**: 1743907; Finkelstein; Duke University
- **Materials to enable voltage-gateable Majorana systems in silicon using top-down fabrication techniques**: 1743986; Alex Levchenko, Maxim Vavilov, Robert McDermott, Susan Coppersmith, Mark Eriksson; University of Wisconsin-Madison
Triplets: Quantum Information Science and Engineering Network

Convergence QL: Workshop Series: Cross-Sector Connections in Quantum Leap; #1747426

- PI: David Awschalom, U. of Chicago
- Budget: $1.6M

Cross-NSF effort:
Managing program: CMP Program, DMR/NSF (T. Durakiewicz)

Participants:
1) OIA/Office of Integrative Activities
2) CMP Program, DMR/Division Of Materials Research
3) EPM Program, DMR/Division Of Materials Research
4) Ceramics Program, DMR/Division Of Materials Research
5) CMMT Program, DMR/Division Of Materials Research
6) CHE/Division Of Chemistry
7) PHY/Division Of Physics
8) ECCS/Div Of Electrical, Commun & Cyber Sys
9) CISE / CCF/Division of Computing and Communication
10) CCF/Division of Computing and Communication
11) OAC/Office of Advanced Cyberinfrastructure
12) SES/Divn Of Social and Economic Sciences
13) OMA/MPS Multidisciplinary Activities

Applications: Nov 6 – Jan 5
http://qisenet.uchicago.edu
DMR “Partnership” Activities

“DMR takes very seriously our mission in serving the U.S. public to advance materials research frontiers and develop the workforce for our nation. This is an important job which is not possible without a strong partnership with all of you from the research communities.” L. Sapochak, DMR Newsletter 2017

Professional Society Conference Activities.
Special presentations:
Session D22: Special Outreach Session--Enabling Careers in Condensed Matter Physics: Federal Programs
Speed Coaching: APS, MRS, AVS

DMR Newsletter.
2nd edition in prep.

DMR Website.
Continual improvement (Early CAREER, Young PI, more to come)

Division / Program Workshops.
Ultra-high magnet field needs (Fall 17)
Materials for Quantum Revolution (May 17)
Mid-scale instrumentation (Dec 2017)
El and Phot. Materials Sept 2017

Division Studies.
e.g. Frontiers of Materials Research: A Decadal Survey, is being supported by the DMR and the Department of Energy, Office of Basic Energy Sciences to help us understand the changing landscape and future needs of materials research in the context of the U.S. and international efforts in important emerging research areas.
Meetings of select CMP Program PIs, NSF, DMR and CMP PDs and “significant others” to:

- share novel/exciting results
- provide info about CMP and other relevant programs within DMR and NSF
- explain the review process, funding decisions, grant management
- pointers on writing successful proposals
- provide community feedback to CMP PDs:
- round table discussions on current/emergent topics
Impactful outreach: examples

**Funsize Physics**

[https://funsizephysics.com/](https://funsizephysics.com/)
Shireen Adenwalla, U. Nebraska

Posts showcasing the wonder, beauty, and potential of cutting-edge materials research—freely contributed by physicists from across the country. (Funsize Physics is not responsible for any minds that are blown.)

**Nanoscale Views**

[http://nanoscale.blogspot.com/](http://nanoscale.blogspot.com/)
Doug Natelson, Rice University

A blog about condensed matter and nanoscale physics. Why should high energy and astro folks have all the fun?

Approx 1000 posts since 2005
THANK YOU!

tdurakie@nsf.gov

Ideas? Questions? Concerns?
Please feel free to contact me in person, call, email - “open door policy”

Note: NSF moved to Alexandria this August
I asked Santa for a research grant.

You still believe in research grants?

© The Upturned Microscope
Presentation Outline

- NSF Organization and Changing Leadership
- DMR Staff, Programs, Budget
- Program Updates
- Program Highlights
- Strategic Research Directions
- DMR “Partnership” Activities
DMREF: GOALI: High Temperature Alloys

https://www.youtube.com/watch?v=deKomQdWd9Y

Search: “materials ready for take off”
MGI: Key Challenges

- Leading a culture shift in materials research to encourage an integrated team approach.
- Integrating experiment, computation, and theory.
- Making digital data accessible.
- Creating a world-class materials workforce that is trained for careers in academia or industry.

Whitepaper

Strategic Plan

5-year Highlights
The Materials Genome Initiative (MGI) has sparked a paradigm shift in the way that materials are discovered, developed, and deployed. By emphasizing computationally-led and data-driven research, MGI is accelerating the pace at which fundamental discoveries are made and transitioned to American manufacturing.

Annual MGI PI Meeting

September 8-9, 2013
NSF PIs
45 Participants

January 12-13, 2015
DOE & NSF PIs
160 Participants

January 11-12, 2016
DOE, NSF, NIST PIs
192 Participants

JOM 2014, 66(3), 336

www.orau.gov/mgi2016

www.orau.gov/mgi2016

The next MGI PI meeting is tentatively scheduled for January 2018.

- Inclusion of more federal agencies.
- Representation from industrial partners.
- Educational session for students and post-docs.
MGI-II Workshop

- MGI-I Workshop held Dec 13-15, 2012 (NSF)
- **May 18-19, 2017** workshop being overseen by Daryl Hess/CMP/DMR.
Advancing MGI: Additional FY18 Objectives

• Enhanced communication with MGI partners
  – FIMAR
  – MGI.gov website
• Data science workshop
  – Connect with CIF21 projects
  – Coordinate with NIST
  – Incorporate ACI and DMS
  – Harnessing the Data Revolution
  – Develop expectations for DMREF Data Management Plans
• Training Next Generation in MGI mindset
  – Perhaps TMS and/or Cornell Studies
• Advancing along Materials Continuum
  – Connection to Advanced Manufacturing Centers
  – Connection with Applied Science/Engineering Agencies (DoD, NASA)
  – I-corps
Developed an automated, large scale platform to extract desired text from scientific journal articles.

From a corpus of ~400,000 inorganic materials science papers -extracted and analyzed synthesis recipes.

High throughput data mining of the obtained synthesis features subsequently enables us to investigate large scale trends in materials synthesis across thousands of papers at once.

Correlate insights with intrinsic and extrinsic materials properties.

Formulate robust relationships between synthesis conditions and the materials they produce. Ultimately-correlations will allow development of novel recipes for the synthesis of current and emerging materials.
Building and using a materials innovation cyberinfrastructure

- Data Infrastructure Building Blocks (DIBBs)
  Data-centric cyberinfrastructure to accelerate collaborative and interdisciplinary Research

- Computation and Data Enabled Science and Engineering (CDS&E)
  Adventurous and Innovative Research Using Computation and Data

- Software Infrastructure for Sustained Innovation (SI2)
  Scientific Innovation Transformed into Sustainable and Reusable Software

Opportunities to Revolutionize How Materials Research is Done to Accelerate Discovery and Innovation

Collaboration ➔ Computational Materials Scientists, Chemists, Cyberinfrastructure Experts, Engineers, Physicists, ...