

Institute for Soldier Nanotechnologies

John D. Joannopoulos

Director, Institute for Soldier Nanotechnologies

Francis Wright Davis Professor of Physics

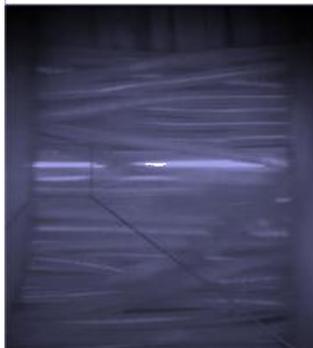
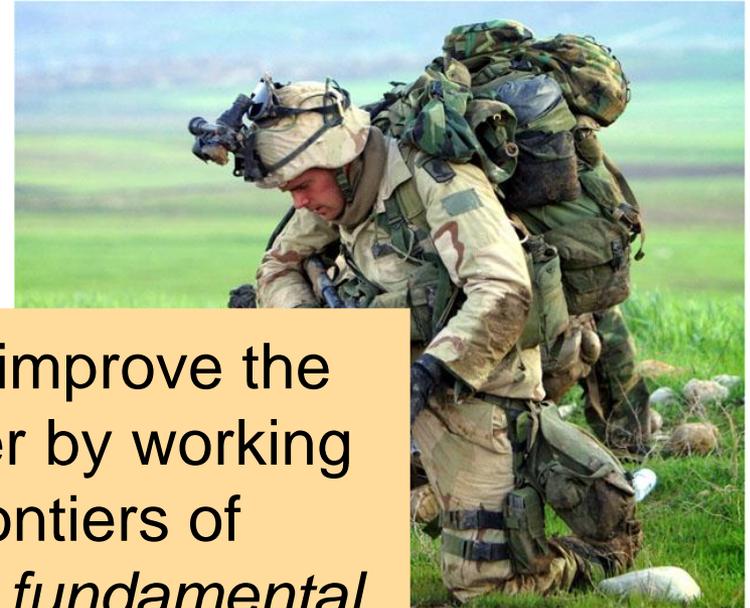
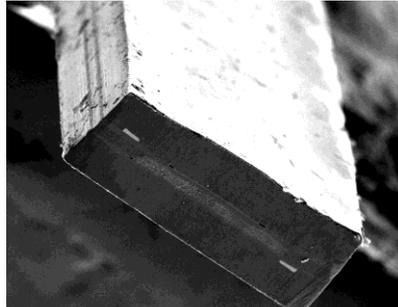
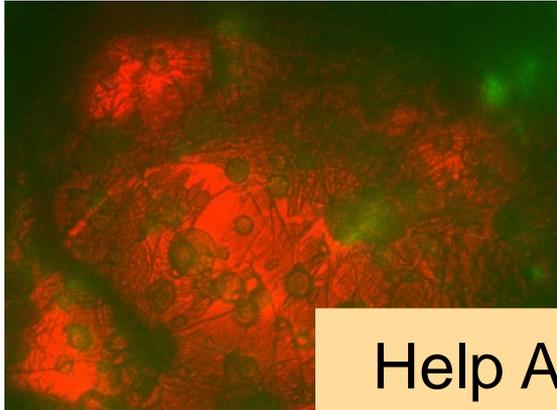
Massachusetts Institute of Technology

***Brief ISN-2 Overview: Research Highlights,
Metrics & Transitions***

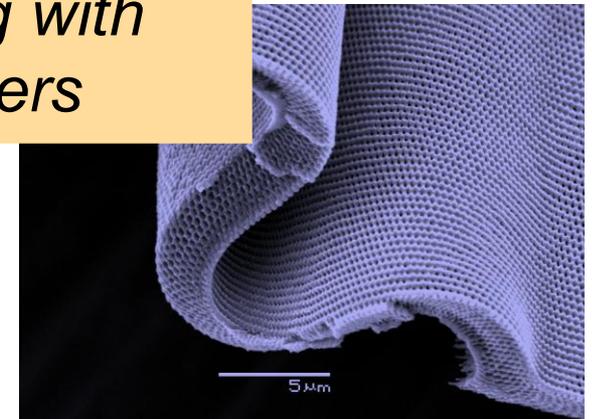
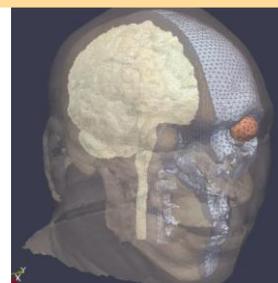
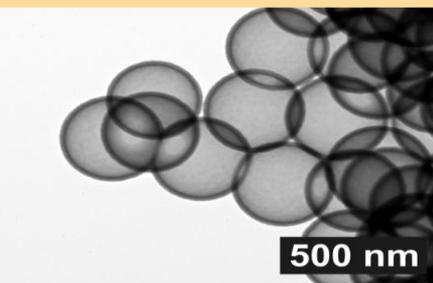
Technical Assessment Board

October 11, 2012

Mission & Goals



Help Army dramatically improve the survivability of the Soldier by working and extending the frontiers of **Nanotechnology** through fundamental research ... and transitioning with our Army & Industry Partners



What is Nanotechnology?

Intrinsic properties of matter (dielectric, mechanical, transport) become **size dependent** below a critical length scale of a few **hundred nanometers**.

(The diameter of a human hair is ~ 90,000 nanometers)

Opportunities:

- **New** materials, **new** phenomena, **new** properties **unattainable** in nature

A Three-Member Team

ISN Dedicated Facility

State of the art instrumentation



- 50 Faculty (12 Departments)
- 110 Grad students
- 40 Post-docs
- 3 Uniformed Army Scientists
- 3 Civilian Army Scientists
- 2 Industry Scientists
- 1 ARL/ARO TTO
- 1 Uniformed Army Liaison Officer

Industry Consortium



Additional Collaborations



The Vision:

Help Army Create Unique Protective Capabilities Using Integrated Systems of Nanotechnologies

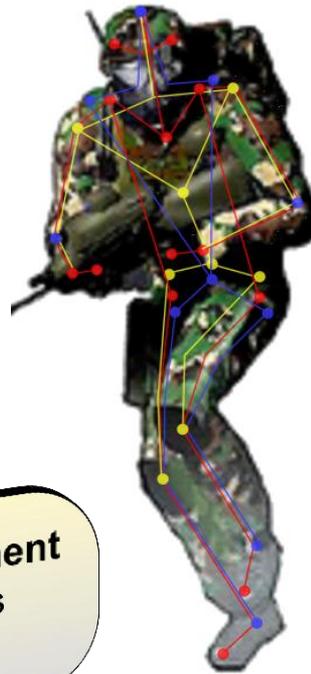
**Chem/Bio/E&M/Nuc
Detection & Protection**
Global & Directional

IR Vision & UV Comm's
Enhanced Situational
Awareness

Health Monitoring & Treatment
Medicines & Healing Agents
Thermal Management

Full-Body Sensing
Enhancing Soldiers' Senses
(light, heat, sound)

Blast & Ballistic Protection
Lightweight Flexible Materials
Mitigation Strategies



The Vision:

Help Army Create Unique Protective Capabilities Using Integrated Systems of Nanotechnologies

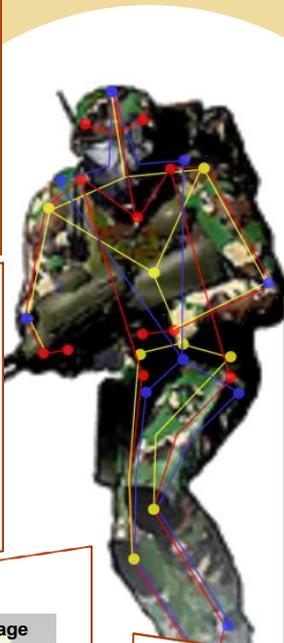


AFPs

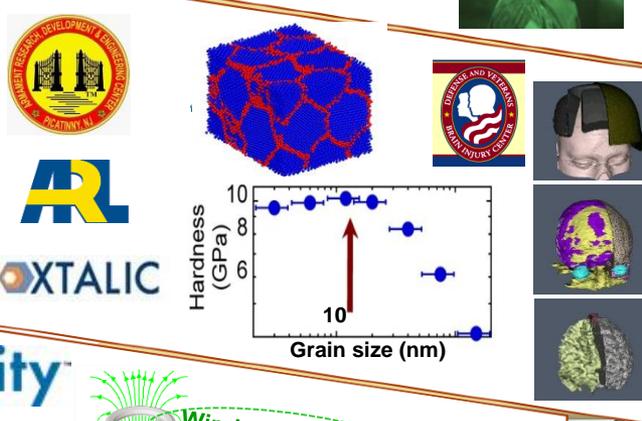
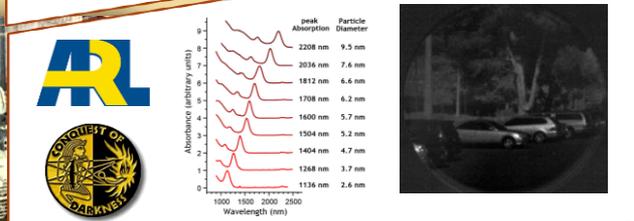
FLIR
Extraordinary Protection

QinetiQ
North America

Fido NXT



US ARMY NATIC Soldier R&D Center



Raytheon

WRAR

Rapid Reconstitution Package



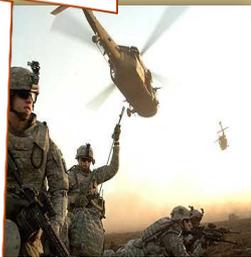
WiTricity

US ARMY NATIC Soldier R&D Center

Wireless Nonradiative Power transfer

QinetiQ
North America

REF
RAPID EQUIPING FORCE



Research & Technology Metrics

2011-2012

180 Manuscripts (*refereed publications*)

- 1 in *Science*
- 5 in *Nature Journals*
- 5 in *PNAS*
- 7 in *Advanced Materials*
- 3 in *Physical Review Letters*

212 Conference Presentations

113 Honors/Awards

35 Technology Disclosures

38 Patent Applications

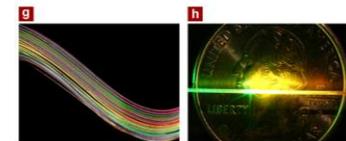
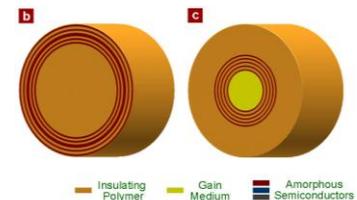
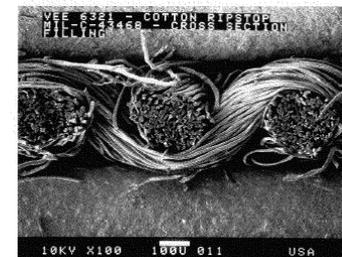
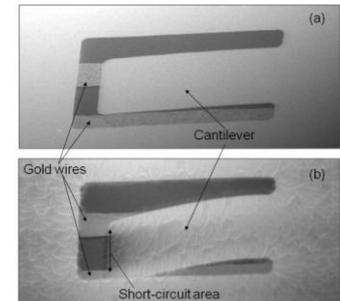
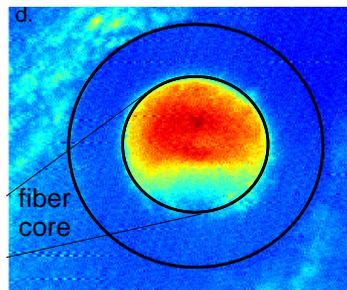
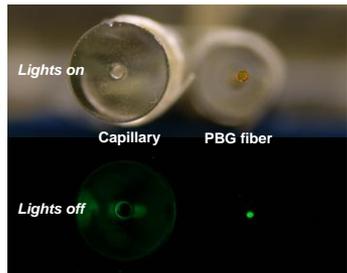
11 Patents Issued

5 License Elections

26 Industry Transitioning ISN Work

7 Industry-Army-ISN 6.2 Projects

- 1 STTR
- 10 Army Funded MIPRs
- 5 USAF Funded MIPRs



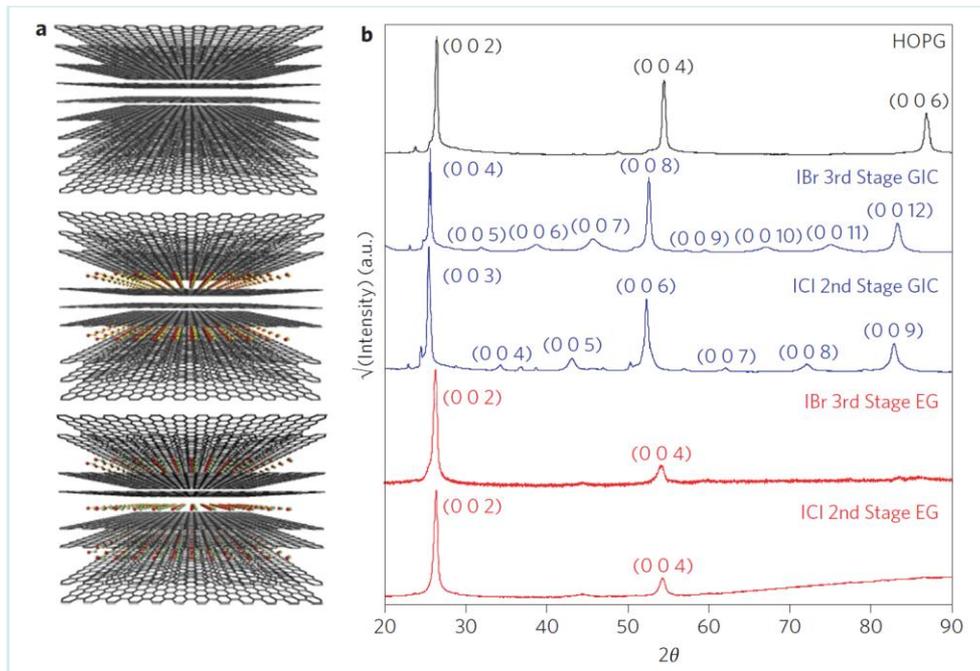
- “Bi- and Trilayer Graphene Solutions,” Shih, Vijayaraghavan, Krishnan, Sharma, Han, Ham, Jin, Lin, Paulus, Reuel, Wang, Blankschtein, Strano MS, *Nature Nanotechnology* **6**, 439-445 (2011).
- “Microworm optode sensors limit particle diffusion to enable in vivo measurements,” Ozaydin-Ince, Dubach, Gleason, Clark, *Proceedings of the National Academy of Sciences* **108**, 7, 2656-2661 (2011).
- “Peptide secondary structure modulates single-walled carbon nanotube fluorescence as a chaperone sensor for nitroaromatics,” Strano, Heller, Pratt, Zhang, Nair, Hansborough, Boghossian, Reuel, Barone, *Proceedings of the National Academy of Sciences* **108**, 8544-8549 (2011).
- “Nonlocal superelastic model of size-dependent hardening and dissipation in single crystal Cu-Al-Ni shape memory alloys,” Qiao, Rimoli, Chen, Schuh, Radovitzky, *Physical Review Letters* **106**, 10 (2011).
- “Frequency-selective near-field radiative heat transfer between photonic crystal slabs: A computational approach for arbitrary geometries and materials,” Rodriguez, Ilic, Bermel, Celanovic, Joannopoulos, Soljačić, Johnson, *Physical Review Letters* **107**, 114302, (2011).
- “Non-polydimethylsiloxane devices for oxygen-free flow lithography,” Bong, Xu, Kim, Chapin, Strano, Gleason, Doyle, *Nature Communications* **3**, 805 (2012).
- “Microfluidic directional emission control of an azimuthally polarized radial fibre laser,” Stolyarov, Wei, Shapira, Sorin, Chua, Joannopoulos, Fink, *Nature Photonics* **6**, 229-233 (2012).
- “Enhancing humoral responses to a malaria antigen with nanoparticle vaccines that expand Tfh cells and promote germinal center induction,” Moon, Suh, Ockenhouse, Yadava, Irvine, *Proceedings of the National Academy of Sciences* **109**, 1080–1085 (2012).
- “Enabling high-temperature nanophotonics for energy applications,” Yeng, Ghebrebrhan, Bermel, Chan, Joannopoulos, Soljagic, Celanovic, *Proceedings of the National Academy of Sciences* **109**, 7, 2280, (2012).
- “Enabling single-mode behavior over large areas with photonic Dirac cones,” Bravo-Abad, Joannopoulos, Soljagic, *Proceedings of the National Academy of Sciences* **109**, 25, 9761, (2012).

“Bi- and Trilayer Graphene Solutions,” Shih, Vijayaraghavan, Krishnan, Sharma, Han, Ham, Jin, Lin, Paulus, Reuel, Wang, Blankschtein, Strano, *Nature Nanotechnology* **6**, 439 (2011)

Bilayer and trilayer graphene is emerging as one of the most promising candidates for nanoelectronics.

Not yet possible to produce large quantities of bilayer or trilayer graphene with controlled stacking, as is required for many applications.

A novel solution-phase technique is introduced for large-area production of bilayer or trilayer graphene through intercalation of graphite with specific ionic compounds.



Electronic properties of the resulting flakes are superior to those achieved with other solution-based methods:

*resistivities as low as $\sim 1 \text{ k}\Omega$
hole mobilities as high as $\sim 400 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$*

This process is expected to allow high-throughput production, functionalization, and enable transfer to arbitrary substrates.

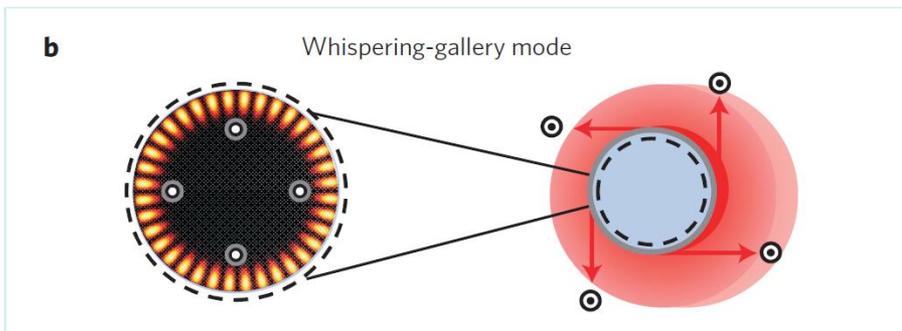
The large flakes isolated in this work enabled the fabrication of field-effect transistor (FET) devices

- “Bi- and Trilayer Graphene Solutions,” Shih, Vijayaraghavan, Krishnan, Sharma, Han, Ham, Jin, Lin, Paulus, Reuel, Wang, Blankschtein, Strano MS, *Nature Nanotechnology* **6**, 439-445 (2011).
- “Microworm optode sensors limit particle diffusion to enable in vivo measurements,” Ozaydin-Ince, Dubach, Gleason, Clark, *Proceedings of the National Academy of Sciences* **108**, 7, 2656-2661 (2011).
- “Peptide secondary structure modulates single-walled carbon nanotube fluorescence as a chaperone sensor for nitroaromatics,” Strano, Heller, Pratt, Zhang, Nair, Hansborough, Boghossian, Reuel, Barone, *Proceedings of the National Academy of Sciences* **108**, 8544-8549 (2011).
- “Nonlocal superelastic model of size-dependent hardening and dissipation in single crystal Cu-Al-Ni shape memory alloys,” Qiao, Rimoli, Chen, Schuh, Radovitzky, *Physical Review Letters* **106**, 10 (2011).
- “Frequency-selective near-field radiative heat transfer between photonic crystal slabs: A computational approach for arbitrary geometries and materials,” Rodriguez, Ilic, Bermel, Celanovic, Joannopoulos, Soljačić, Johnson, *Physical Review Letters* **107**, 114302, (2011).
- “Non-polydimethylsiloxane devices for oxygen-free flow lithography,” Bong, Xu, Kim, Chapin, Strano, Gleason, Doyle, *Nature Communications* **3**, 805 (2012).
- “Microfluidic directional emission control of an azimuthally polarized radial fibre laser,” Stolyarov, Wei, Shapira, Sorin, Chua, Joannopoulos, Fink, *Nature Photonics* **6**, 229-233 (2012).
- “Enhancing humoral responses to a malaria antigen with nanoparticle vaccines that expand Tfh cells and promote germinal center induction,” Moon, Suh, Ockenhouse, Yadava, Irvine, *Proceedings of the National Academy of Sciences* **109**, 1080–1085 (2012).
- “Enabling high-temperature nanophotonics for energy applications,” Yeng, Ghebrebrhan, Bermel, Chan, Joannopoulos, Soljagic, Celanovic, *Proceedings of the National Academy of Sciences* **109**, 7, 2280, (2012).
- “Enabling single-mode behavior over large areas with photonic Dirac cones,” Bravo-Abad, Joannopoulos, Soljagic, *Proceedings of the National Academy of Sciences* **109**, 25, 9761, (2012).

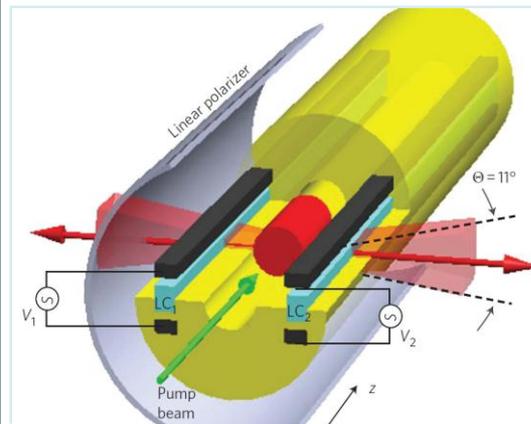
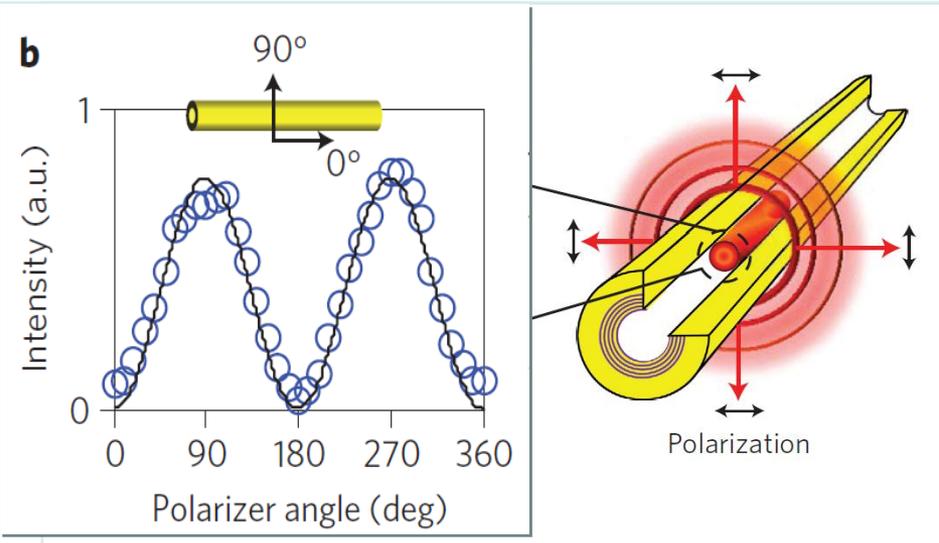
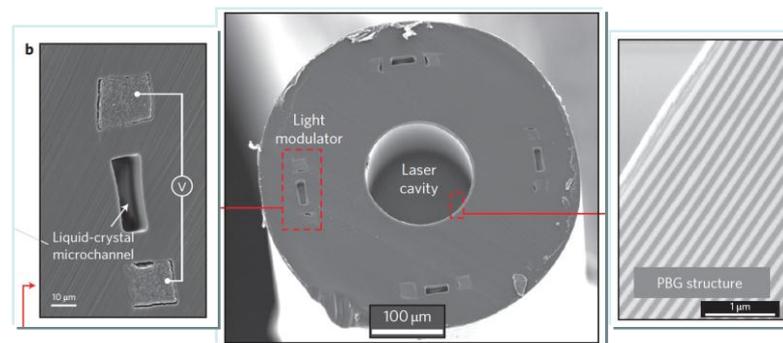
“Microfluidic directional emission control of an azimuthally polarized radial fibre laser,”
 Stolyarov, Wei, Shapira, Sorin, Chua, Joannopoulos, Fink, *Nature Photonics* **6**, 229 (2012)

Lasers with cylindrically symmetric polarization states are predominantly based on whispering-gallery modes

The fibre core is then encircled by an array of electrically contacted and independently addressable liquid-crystal microchannels embedded in the fibre cladding.



Here, a **zero-angular-momentum** laser with purely radial emission is demonstrated.



The new single-fiber capability, opens opportunities ranging from flexible multidirectional displays to minimally invasive directed laser ablation for medical applications.

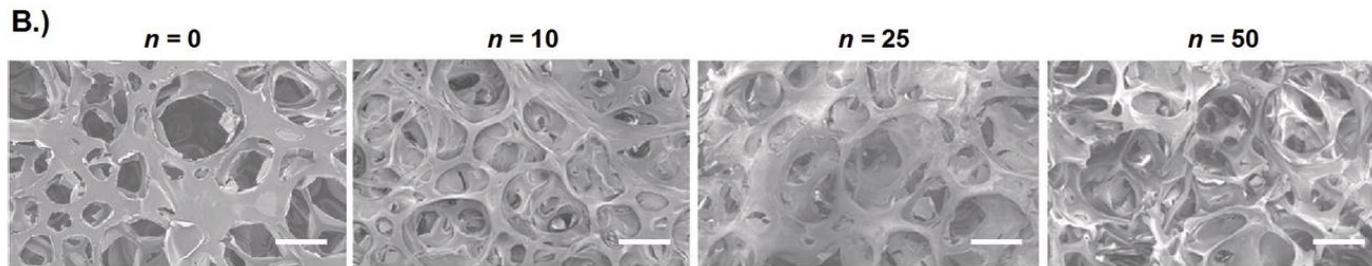
- “Waveguiding at the Edge of a Three-Dimensional Photonic Crystal,” Lu, Joannopoulos, Soljacic, *Physical Review Letters* **108**, 243901, (2012).
- “Hemostatic Multilayer Coatings,” A. Shukla, J. C. Fang, S, Puranam, F. Jensen, and P. T. Hammond, *Advanced Materials*, **24**, 492 (2012).
- “Engineering Nano- and Microparticles to Tune Immunity,” Moon, Huang, Irvine, *Advanced Materials* **24**, 3724-3746 (2012).
- “Understanding and Controlling the Substrate Effect on Graphene Electron Transfer Chemistry via Reactivity Imprint Lithography,” Wang, Jin, Kim, Hilmer, Paulus, Shih, Ham, Sanchez-Yamagishi, Watanabe, Taniguchi, Kong, Jarillo-Herrero, Strano, *Nature Chemistry*, **4**, 724 (2012).
- “Design of Stable Nanocrystalline Alloys,” T. Chookajorn, H. A. Murdoch, C. Schuh, *Science*, **337**, 951 (2012).
- “High strain rate deformation of layer Nanocomposites,” Lee, Veysset, Retsch, Sani, Singer, Pezeril, Nelson, Thomas, *Nature Communications*, in press (2012).
- “Piezoelectric fibers for conformal acoustics,” N. Chocat, G. Lestoquoy, Z. Wang, D. Rodgers, J. D. Joannopoulos, Y. Fink, *Advanced Materials*, in press (2012).
- “The design and synthesis of hard and impermeable, yet flexible, conformal organic coatings,” Xu, Asatekin, Gleason, *Advanced Materials*, in press (2012).
- “Micro-/nano-structured mechanical metamaterials,” Lee, Singer, Thomas *Advanced Materials*, in press (2012).
- “Grafted Crystalline Poly-Perfluoroacrylate Structures for Superhydrophobic and Oleophobic Functional Coatings,” Coclite, Shi, Gleason, *Advanced Materials*, in press (2012).
- “Controlling spatial organization of multiple cell types in defined 3D geometries,” Tekin, Sanchez, Landeros, Dubbin, Langer, Khademhosseini, *Advanced Materials*, in press (2012).

- “Waveguiding at the Edge of a Three-Dimensional Photonic Crystal,” Lu, Joannopoulos, Soljacic, *Physical Review Letters* **108**, 243901, (2012).
- “Hemostatic Multilayer Coatings,” A. Shukla, J. C. Fang, S, Puranam, F. Jensen, and P. T. Hammond, *Advanced Materials*, **24**, 492 (2012).
- “Engineering Nano- and Microparticles to Tune Immunity,” Moon, Huang, Irvine, *Advanced Materials* **24**, 3724-3746 (2012).
- “Understanding and Controlling the Substrate Effect on Graphene Electron Transfer Chemistry via Reactivity Imprint Lithography,” Wang, Jin, Kim, Hilmer, Paulus, Shih, Ham, Sanchez-Yamagishi, Watanabe, Taniguchi, Kong, Jarillo-Herrero, Strano, *Nature Chemistry*, **4**, 724 (2012).
- “Design of Stable Nanocrystalline Alloys,” T. Chookajorn, H. A. Murdoch, C. Schuh, *Science*, **337**, 951 (2012).
- “High strain rate deformation of layer Nanocomposites,” Lee, Veysset, Retsch, Sani, Singer, Pezeril, Nelson, Thomas, *Nature Communications*, in press (2012).
- “Piezoelectric fibers for conformal acoustics,” N. Chocat, G. Lestoquoy, Z. Wang, D. Rodgers, J. D. Joannopoulos, Y. Fink, *Advanced Materials*, in press (2012).
- “The design and synthesis of hard and impermeable, yet flexible, conformal organic coatings,” Xu, Asatekin, Gleason, *Advanced Materials*, in press (2012).
- “Micro-/nano-structured mechanical metamaterials,” Lee, Singer, Thomas *Advanced Materials*, in press (2012).
- “Grafted Crystalline Poly-Perfluoroacrylate Structures for Superhydrophobic and Oleophobic Functional Coatings,” Coclite, Shi, Gleason, *Advanced Materials*, in press (2012).
- “Controlling spatial organization of multiple cell types in defined 3D geometries,” Tekin, Sanchez, Landeros, Dubbin, Langer, Khademhosseini, *Advanced Materials*, in press (2012).

“**Hemostatic Multilayer Coatings**,” A. Shukla, J. C. Fang, S, Puranam, F. Jensen, and P. T. Hammond, *Advanced Materials*, **24**, 492 (2012).

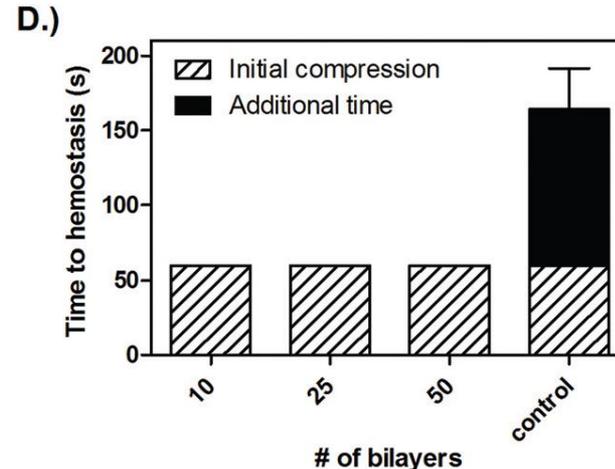
A new method of hemostasis involving a water-based thin film assembly method to coat active clotting proteins onto a water-sorbable gelatin sponge was developed.

Can be used on a wide range of substrates, even those that change structure in the presence of water, while enabling introduction of a range of macromolecules, from proteins to polysaccharides to create highly effective hemostatic dressings, providing fast bleeding relief for a variety of wounds.



of bilayers

of bilayers



- “Waveguiding at the Edge of a Three-Dimensional Photonic Crystal,” Lu, Joannopoulos, Soljacic, *Physical Review Letters* **108**, 243901, (2012).
- “Hemostatic Multilayer Coatings,” A. Shukla, J. C. Fang, S, Puranam, F. Jensen, and P. T. Hammond, *Advanced Materials*, **24**, 492 (2012).
- “Engineering Nano- and Microparticles to Tune Immunity,” Moon, Huang, Irvine, *Advanced Materials* **24**, 3724-3746 (2012).
- “Understanding and Controlling the Substrate Effect on Graphene Electron Transfer Chemistry via Reactivity Imprint Lithography,” Wang, Jin, Kim, Hilmer, Paulus, Shih, Ham, Sanchez-Yamagishi, Watanabe, Taniguchi, Kong, Jarillo-Herrero, Strano, *Nature Chemistry*, **4**, 724 (2012).
- “Design of Stable Nanocrystalline Alloys,” T. Chookajorn, H. A. Murdoch, C. Schuh, *Science*, **337**, 951 (2012).
- “High strain rate deformation of layer Nanocomposites,” Lee, Veysset, Retsch, Sani, Singer, Pezeril, Nelson, Thomas, *Nature Communications*, in press (2012).
- “Piezoelectric fibers for conformal acoustics,” N. Chocat, G. Lestoquoy, Z. Wang, D. Rodgers, J. D. Joannopoulos, Y. Fink, *Advanced Materials*, in press (2012).
- “The design and synthesis of hard and impermeable, yet flexible, conformal organic coatings,” Xu, Asatekin, Gleason, *Advanced Materials*, in press (2012).
- “Micro-/nano-structured mechanical metamaterials,” Lee, Singer, Thomas *Advanced Materials*, in press (2012).
- “Grafted Crystalline Poly-Perfluoroacrylate Structures for Superhydrophobic and Oleophobic Functional Coatings,” Coclite, Shi, Gleason, *Advanced Materials*, in press (2012).
- “Controlling spatial organization of multiple cell types in defined 3D geometries,” Tekin, Sanchez, Landeros, Dubbin, Langer, Khademhosseini, *Advanced Materials*, in press (2012).

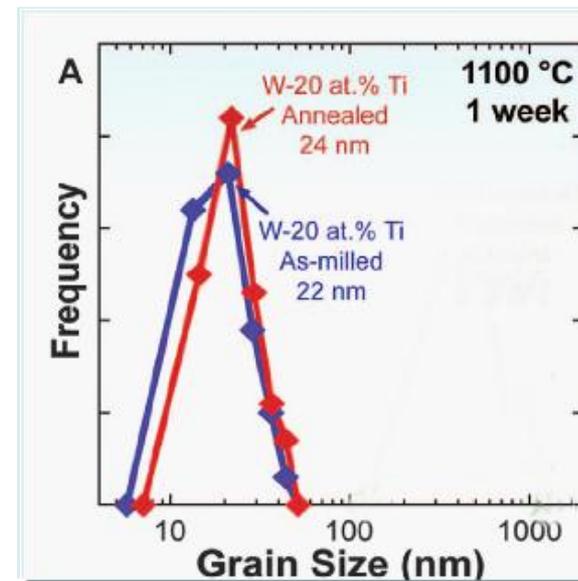
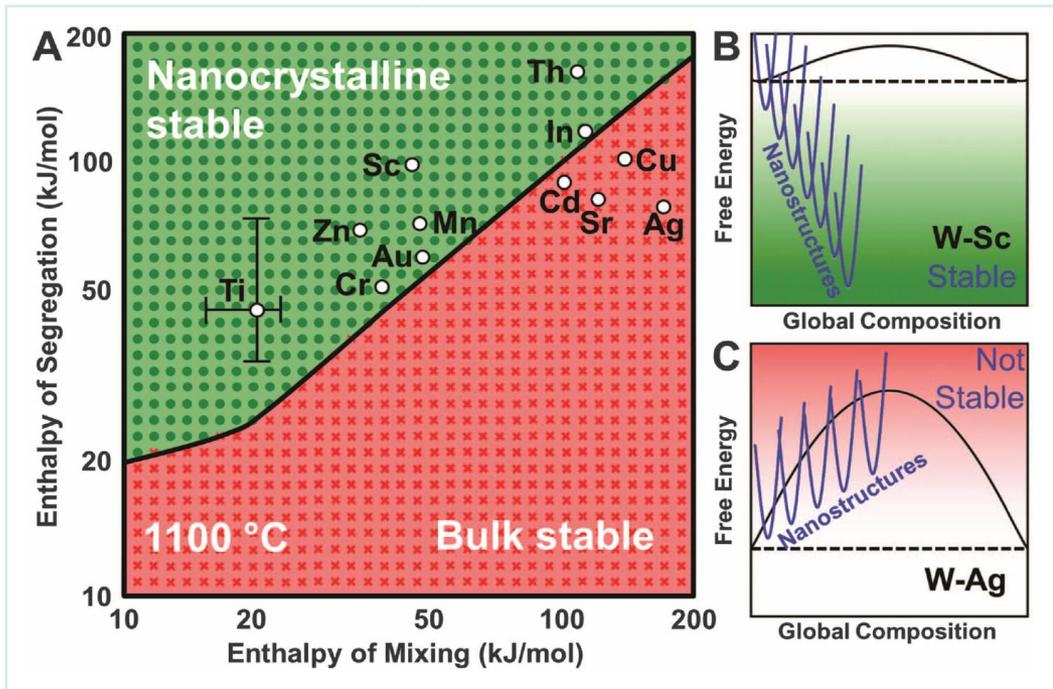
“Design of Stable Nanocrystalline Alloys,” T. Chookajorn, H. A. Murdoch, C. Schuh, *Science*, **337**, 951 (2012).

Nanostructured metals are generally unstable, and grains grow rapidly even at low temperatures.

Alloying has been found to improve stability, but only in a few empirically discovered systems.

Here a new theoretical framework is introduced with which thermodynamically stable nanostructured alloys can be predicted and selected a-priori.

Nanostructure Stability Map at 1100° C



Amenable to powder-route production of bulk nanostructured tungsten!

A Few Detailed Examples

U. S. Patent Applications:

- ◆ ISN 1.1.1 Bhattacharyya, Gleason *“High Surface Area Flexible Chemiresistive Biosensing by oCVD”*
- ◆ ISN 1.2.1 Bawendi, Harris *“Synthesis of CdAs Quantum Dots & CdAs/CdP Core-Shell Quantum Dots Luminescent in the IR”*
- ◆ ISN 1.2.2 Kastner, Maclean, Mentzel, Ray *“Contact-Independent Electrical Conductance Measurement”*
- ◆ ISN 1.2.3 Akselrod, Bawendi, Bulovic, et al. *“Luminescence Enhancement by FRET from an Absorptive Thin Film”*
- ◆ ISN 2.1.1 Hunter, Chang *“Conducting Polymer with Actively Switchable Absorbency”*
- ◆ ISN 2.2.1 Hammond, Shukla *“Coating Compositions, Methods, and Coating Devices”*
- ◆ ISN 2.3.3 Mirica, Swager *“Deposition of Conductive Nanocomposites for Circuits and Sensors for Abrasion”*
- ◆ ISN 3.1.1 Cox, Swager *“Photoalignment of Materials Including Liquid Crystals”*
- ◆ ISN 3.3.1 Cai, Schuh *“Tuning Nano-scale Grain Size Distribution in Multilayered Alloys, Including Al-Mn and Similar Alloys”*
- ◆ ISN 4.1.1 Gleason, Petruczuk *“3-Dimensional Photoresist via Functionalization of Polymer Thin Films Fabricated by iCVD ”*
- ◆ ISN 4.1.3 Hsu, Klibanov, Schaer, Stewart *“Hydrophobic Polycationic Coatings for Biofilm Inhibition”*
- ◆ ISN 4.2.1 Bawendi, Bulovic, Dorn, Walker *“Color-Selective Coupled J-Aggregate/Nanowire Photodetectors”*
- ◆ ISN 4.3.1 Barbastathis, Chang, Choi, Kim, McKinley *“Process for Fabricating High Aspect-Ratio Tapered Nanocones”*
- ◆ ISN 5.2.1 Danto, Fink, Joannopoulos, Orf, Shapira, Sorin *“Fiber Draw Synthesis”*
- ◆ ISN 5.3.1 Danto, Fink, Joannopoulos, Lestoquoy, Sorin *“Photodetecting Fiber”*
- ◆ ISN 5.4.1 Hamam, Joannopoulos, Karalis, Soljacic *“Wireless Energy Transfer Including Interference Enhancement”*

U. S. Patents Issued:

- ◆ ISN 3.1.2 Dendukuri, Seamus, Doyle, Jang, Thomas, *“Stop Flow Interference Lithography Method”*
- ◆ ISN 4.3.1 Arora, Barbastathis, *“Method of Forming a Locally Periodic 3D Structure with Large-Scale Variation”*
- ◆ ISN 5.1.1 Baldo, Bora, Celebi, Mapel, *“Excitonic Surface Plasmon Resonance Biosensing Mechanism”*
- ◆ ISN 5.4.1 Hashemi, Joannopoulos, Johnson, Rodriguez, Soljacic, *“Nonlinear Harmonic Generation in Resonant Kerr Cavities”*

A Few Detailed Examples

STTRs:

- ◆ ISN 5.4.1 Creare, Inc. *“Advanced Radiative Emitters for Radioisotope Thermophotovoltaic Power Systems”* NASA Phase II

Army MIPRs:

- ◆ ISN 1.1.1 Rutledge *“High Performance Polymer Nanofibers for Ballistic & Blast Protection,”* NSRDEC
- ◆ ISN 1.5.1 McKinley *“Development Of Superoleophobic Coated Materials,”* NSRDEC
- ◆ ISN 2.3.2 Langer *“3D Hydrogel Scaffolding for Cell and Tissue Support,”* ERDC USACE
- ◆ ISN 3.1.1 Swager *“Testing Of Novel ISN Sensing Devices,”* ECBC
- ◆ ISN 3.2.1 Socrate *“Strain-Rate Dependent Mechanical Behavior,”* ARL-WMRD
- ◆ ISN 4.1.2 Khademhosseini *“Biometric Living Cell Systems for Detection,”* ERDC USACE

USAFMS MIPRs:

- ◆ ISN 1.4.1 Fink *“Novel Ultrasound Transducing Fabrics,”* AFMSA
- ◆ ISN 2.2.2 Irvine *“Materials for Simplified & Noninvasive Drug Delivery,”* AFMSA
- ◆ ISN 2.3.1 Cima *“Device For Non-Invasive Rapid Determination of Hydration,”* AFMSA

New Method of Hydration Monitoring

**Development of Portable Devices for
non-invasive rapid determination of patient hydration**

***Nuclear Magnetic Relaxation (NMR) techniques allow for a fast,
economical, and non-invasive measurement of hydration status***

M. Cima

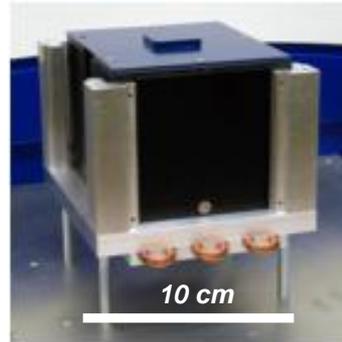


***Adequate Hydration
for Optimal Combat
Effectiveness***

***Hydration Status for
Enroute Treatment***



**NMR Measurement
Device (*ex-situ*)**



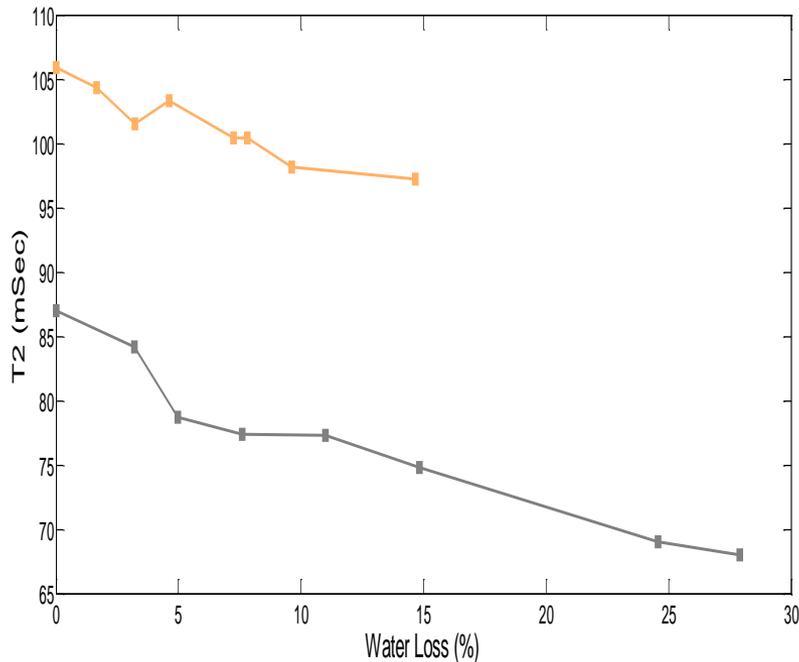
Quantifying Dehydration with *In vivo* Changes in T2



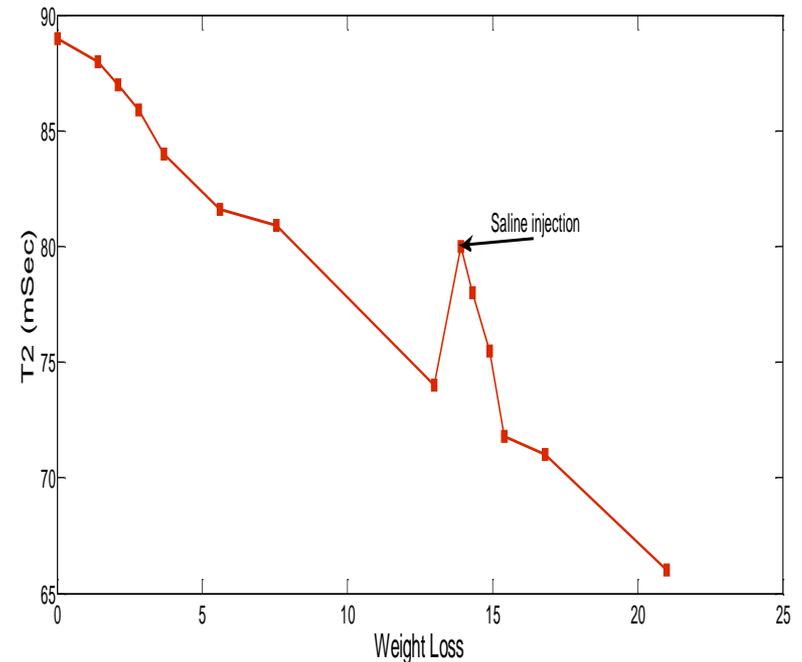
U.S. AIR FORCE

- Murine model in metabolic cages
- $\Delta\text{weight} = \text{food} - \text{feces} - \text{urine} - \text{water loss}$

Over-hydration Experiment:
500 μL Saline Injected



T2 versus water loss for two animals



New Method of Hydration Monitoring

M. Cima

Development of Portable Devices for non-invasive rapid determination of patient hydration

Nuclear Magnetic Relaxation (NMR) techniques allow for a fast, economical, and non-invasive measurement of hydration status



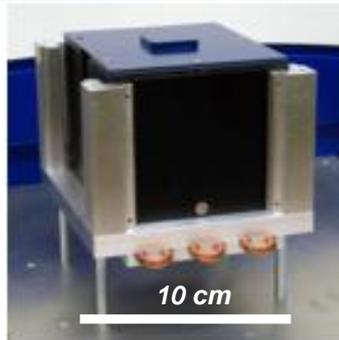
Dr. M. Sawka

Adequate Hydration for Optimal Combat Effectiveness

Hydration Status for Enroute Treatment

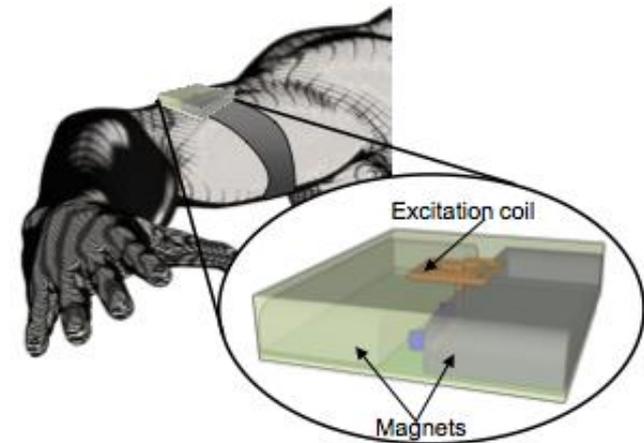


NMR Measurement Device (ex-situ)



Explore USARIEM Collaboration & use of its Protocols

Develop Wearable MEMS Hydration ex-situ Monitor



Research & Technology Metrics

2011-2012

9 Masters Degrees Completed

Destinations include: Oliver Wyman, SpaceX

28 Doctoral Degrees Completed

Faculty Position: Mahatma Education Society-PIIT

Post-docs: MIT (x6), Imperial College London, Berkeley, Stanford, Minnesota, Rice, NSRDEC, USACE

*Other Destinations include: Oracle, Saint Gobain (x2), McKinsey, Abpro, Boston Consulting Group, Dow Chemical, GE Healthcare, 3M, Taris Biomedical, A*STAR-Singapore*

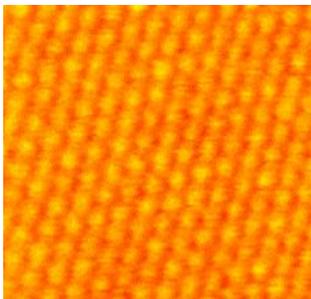
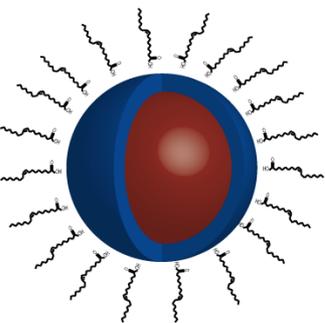
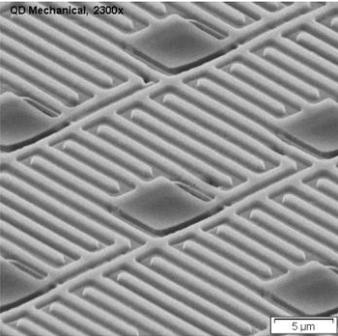
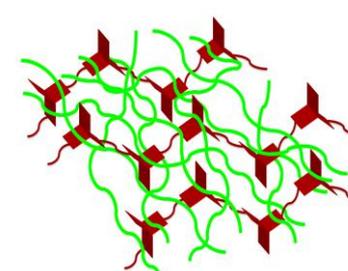
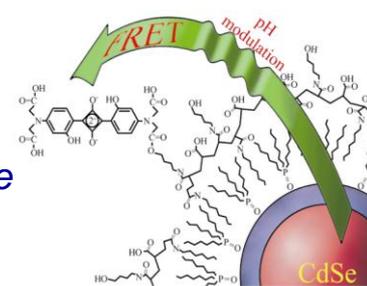
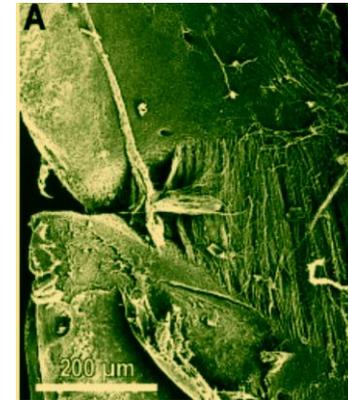
40 Post Doctorates Trained

32 Post Doctorates Departed

Faculty Positions: MIT (x2), GA Tech, Drexel, Clarkson, University of New Hampshire, UT-Austin, École Polytechnique Fédérale de Lausanne, Clemson, University of Bonn, Al-Mustansiriya University, University of Nebraska-Lincoln, University of Sungkyunkwan University, Kyungwon University, Hanyang University, University of Akron

Non-faculty Positions Include: MIT, SkTech/MIT Initiative, Institute of Bioengineering and Nanotechnology-Singapore, 3M, Taris Biomedical, Samsung Petrochemical, W.L. Gore & Associates, QD Vision

4 Uniformed Graduate Students



Research & Technology Metrics

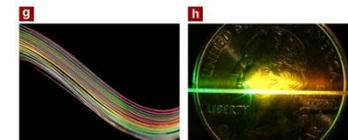
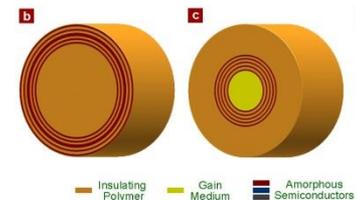
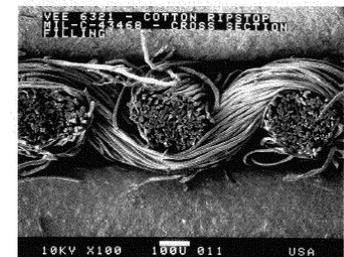
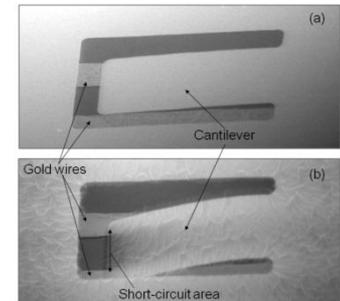
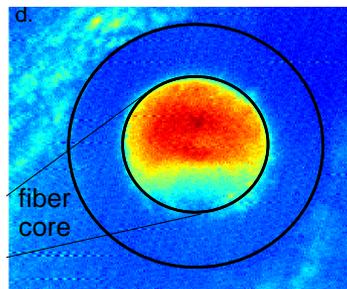
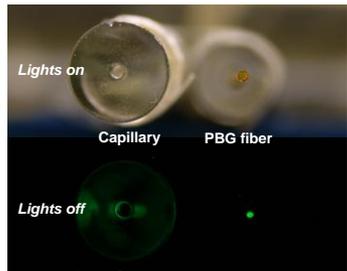
2011-2012

- 9 ISN-Army Labs Student Summer Interns
- 6 ERDC-Concord, 1 ARL-WMRD, 1 NSRDEC, 1 ARDEC-Benét Labs

- 2 USMA Cadets - ISN Summer Research Introduction Program (SRI)
(Advanced Individual Academic Development (AIAD) Program)

Ongoing Collaborations Resulting from Army-ISN & Army-ICB-ISN Topical Workshops Include:

- *B. DeLacy (ECBC)/M. Soljacic & J. Joannopoulos (ISN) – photonic crystal obscuration*
- *B. DeLacy (ECBC)/V. Bulovic (ISN) – J-particle aggregate obscuration*
- *Chris Haines (ARDEC)/S. Kooi (ISN) – B₄C nanoparticles*
- *Chiara Daraio (ICB)/S. Kooi (ISN) – MWCNTs*
- *J. Lenhart (ARL-WMRD)/S. Socrate (ISN) – Tissue simulant gels*
- *A. Kumar & J. Trovillion (ERDC)/S. Socrate – Hierarchical CNT composites*



Research & Technology Metrics

2011-2012

Leveraging of Industrial Funding

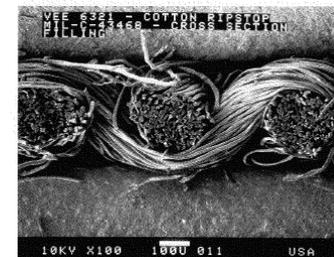
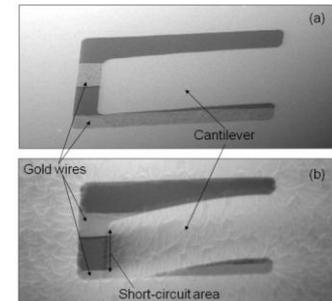
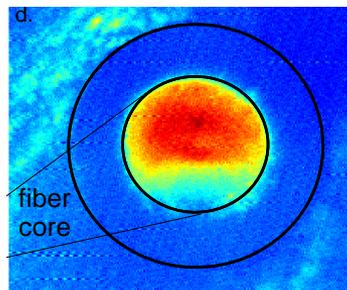
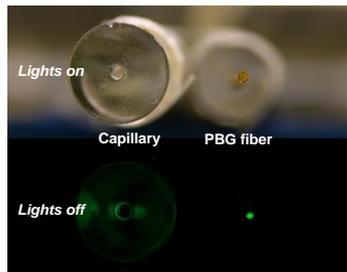
11 Visiting Scientists (15% FTE each)

\$79K Support of Soldier Design Competition

\$300K Discretionary Funding

\$150K Direct Support of Research Project:

- *Helium-CF₄ Time Projection Chamber Testing: P. Fisher – Raytheon*

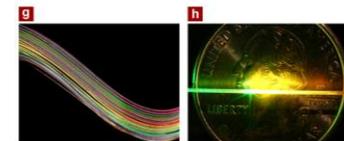
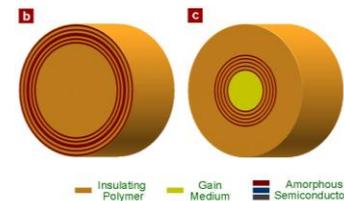


MIT Co-Investment (Annual)

29.4% Matching of Army Core 6.1 Funding
(22.7% *Cost Sharing of Core 6.1 Expenditures*)

\$2.8M For \$9.51M Army Core 6.1

\$50K Discretionary Funding



A Sampling of FY'12 ISN-2 Transitions

- Novel ISN **mathematical modeling** of ballistic response of **Kevlar composites** for armor design to ARL-WMRD. Predicted (ISN) & measured (ARL) gas-gun impact tests in excellent agreement.
- Unique ISN **blast-TBI computational modeling** to NSRDEC for aid in the design of **shock tube instrumentation** for blast injury testing.
- Efficient ISN **wireless non-radiative power transfer** techniques to NSRDEC & WiTricity Corp for transfer of electric power between power generators on the Soldier's torso and devices on the Soldier's helmet without wires.
- ISN **Rapid Reconstitution Package (RRP)** prototypes to MRMC-WRAIR for **testing in malaria vaccine delivery** and follow-up optimization. Testing & characterization at WRAIR is underway.
- Novel trace **explosive sensing system** to ECBC for **testing and evaluation** of prototype sensor in presence of live C4. Limits of cyclohexanone (explosives constituent) detectability determined at 5ppm with an S/N greater than two.
- ISN **fabrication technology transfer** to ARL-SEDD for fabrication & characterization of novel high-performance flexible & transparent MoS₂ devices at ARL.

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|---|--|---|---|
| <p>K. Nelson N. Thomas S. Kooi</p> | <p>ARL-WMRD (A. Hsieh, ahsieh@arl.army.mil)</p> <p>ARL-WMRD (D. Dandekar, ddandek@arl.army.mil)</p> | <p>Improved future ceramic body armor materials. Improved PMMA transparent armor materials (for face-shields and windows)</p> | <p>Studies of shock-induced failure mechanisms using optical & electron spectroscopic methods. Thin ceramic and polymeric samples sent from ARL to ISN for analysis. Continuing collaboration for shockwave testing at the ISN of new ARL-fabricated samples.</p> |
| <p>S. Kooi</p> | <p>ARL-NSRDEC (R.M. Osgood, richard.m.osgood.civ@mail.mil)</p> | <p>Novel materials and structures for SERS based sensor platforms.</p> | <p>Natick and ISN have analyzed the Raman behavior of SERS substrates produced at Natick. Currently, ISN is fabricating patterned substrates for the ordering of SERS active particles from Natick.</p> |
| <p>Y. Fink OmniGuide, Inc. (Doug Hutchison)</p> | <p>Madigan Army Medical Center (Dr. Mark Crawford) and numerous Veterans Administration Hospitals across the USA.</p> | <p>Enabling minimally invasive CO2 laser endoscopic surgery tools</p> | <p>Development of 'BeamPath Fiber' CO2 laser scalpel for novel surgical procedures in otology, neurotology, laryngology, head & neck, and neurology (2009-2012).</p> |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--|--|---|---|
| M. Bawendi V. Bulovic M. Kastner | Raytheon (F. Jaworski, Frank B Jaworski@raytheon.com); ARL-SEDD (P.S. Wijewarnasuriya, pwijewarnasuriya@arl.army.mil ; GV Jagannathan, gomatam.jagannathan@us.army.mil) | IR & UV Imager based on nanocrystal quantum dots for night vision <i>and</i> communications | Plane Array to ISN for coating. New UV-IR downconversion dots to Raytheon for testing. In 2011, UV imaging with IR FPA demoed. SEDD & Raytheon collabs. ongoing; QD & QD device technology to QD Vision (MIT Startup) |
| R. Langer | USACE-CERL (D. Cropek, Donald.M.Cropek@erdc.usace.army.mil) | Effective tissue regeneration and wound healing for the Soldier | Continued USACE MIPR'd funds to fabricate 3D cell-laden multi-structured bio-scaffolds (funding provided in 2009-2012) |
| A. Khademhosseini | USACE-CERL (D. Cropek, Donald.M.Cropek@erdc.usace.army.mil) | Portable, cardiac-cell based sensor for toxins in water and body fluids | Device prototypes developed. USACE MIPR'd funds to augment current ISN effort to continue development of prototype devices (2009-2012). |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--|--|---|--|
| K. Gleason | NSRDEC (K. Senecal, Kris.Senecal@us.army.mil) | Resistivity-based sensors for pathogens. | <i>Bhattacharyya, D., Senecal, K., Marek, P., Senecal, A., Gleason, K.K.; High surface area flexible chemiresistive biosensor by oxidative chemical vapor deposition, Adv. Functional Materials (Cover) 2011, 21, 4328-4337.</i> Collaboration established with Brian Baker, FDA Center Director, WEAC, ORISE Fellow to work between FDA, NSRDEC, and MIT to advance food pathogen sensors 2012-2013. |
| K. Gleason TSI (J. Lock, N. Rice, P. Schuler) | ARL-WMRD (A. Rawlett, arawlett@arl.army.mil) NSRDEC (B. Kimball, Brian.R.Kimball@us.army.mil) | Flexible dielectric Bragg reflectors for laser eye protection | Continued extension of optical performance and uniformity of iCVD polymer and oxide optical filter constituents by TSI/ISN. Samples transferred to ARL for analysis of inter-layer adhesion and NSRDEC for performance testing. |
| K. Gleason | ARL-Aberdeen (Thomas C. Parker, Daniel Baechle, John Derek Demaree) | ISN iCVD technology used for Barrier Coatings on Powders | Polymeric barrier coatings via initiated chemical vapor deposition: Parker Thomas C.; Baechle Daniel; Demaree John Derek, SURFACE & COATINGS TECH. (2011) 206, 1680. |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--|---|--|---|
| <p>C. Schuh R. Radovitzky</p> | <p>ARDEC Picatinny Arsenal (D. Kapoor, deepak.kapoor@us.army.mil), C. Haines, chris.haines@us.army.mil; ARL/ARO (S. Mathaudhu, suveen.mathaudhu@arl.army.mil) ARL-WMRD (T. Weerasooriya, tusitw@arl.army.mil) Xtalic Corp (A. Lund, alund@xtalic.com)</p> | <p>Exploiting novel nanoparticle mechanical properties for lightweight, strong & flexible protection for the Soldier and vehicles.</p> | <p>Continuing collaboration with Picatinny (Kapoor, Haines) scale-up of ISN powders of nano-crystalline Al-Mn & with ARL (Mathaudhu) to explore shape memory architectures, including foams and trusses. Xtalic scale-up of electrochemical fabrication underway.</p> |
| <p>S. Socrate R. Radovitzky E. Parsons</p> | <p>ARL-WMRD (T. Weerasooriya, tusitw@arl.army.mil; P. Moy, paul.moy@us.army.mil)</p> | <p>Mathematical models of ballistic response of textile composites for armor design</p> | <p>Multi-ply fabric predicted (ISN) & measured (ARL) gas-gun impact tests in excellent agreement (2010). Modeling (ISN) of Kevlar composites with tests conducted at ARL show good predictive abilities (2011-2012).</p> |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--|--|--|--|
| R. Radovitzky | NSRDEC (Barry DeCristofano, barry.s.cristofano@us.army.mil , Marina Carboni, marina.g.carboni.civ@mail.mil John Fitek, John.Fitek@us.army.mil) | Shock tube and blast experiments on headforms | ISN Blast-TBI computational modeling framework and models ported to NSRDEC (2011). Currently assisting collaborators in design of shock tube for blast injury testing using ISN simulation tools |
| R. Radovitzky S. Socrate | ARL-CISD (R. Namburu, raju.r.namburu.civ@mail.mil) | Port novel blast & ballistic codes (SumMIT) to the ARL Major Shared Resource Center (MSRC) to run and make available to the Army and broader DoD community | Conducted wide range of calculations on the protection effects of helmets <i>with and without</i> face-shields under blast conditions (2010-2012). |
| R. Radovitzky, J. Rimoli, A. Seagraves | ARL-WMRD (A.Hsieh, ahsieh@arl.army.mil) | Transparent armor fracture response | Continuing validation of ISN Discrete-Galerkin / Cohesive-Zone-Method code for predicting radial and conical cracks in PMMA and PC plate impact (2010-2012). |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--|---|--|---|
| R. Radovitzky, S. Socrate A. Rosolen M. Nyein (MIT) A. Jean W. Pino | ARL ("Kraft, Reuben (Civ, ARL/WMRD)" <reuben.kraft@us.army.mil>, "Dagro, Amy (Cont, ARL/WMRD)" <amy.m.dagro.ctr@us.army.mil>, | Lower limb injury biomechanics | Adapted DG/CZM fracture code with advance model of trabecular and cortical bone response to simulate lower limb impact response from underbelly explosions. |
| R. Radovitzky, A. Seagraves | ARL-WMRD ("Becker, Richard (Civ, ARL/WMRD)" < richard.c.becker@us.army.mil >, | Dynamic brittle fracture modeling | Continuing validation of ISN Discrete-Galerkin / Cohesive-Zone-Method code for predicting radial and conical cracks in brittle plate impact (2011-2012). |
| S. Socrate R. Radovitzky E. Parsons | ARL-WMRD (Alex Hsieh, ahsieh@arl.army.mil, Joe Lenhart joseph.lenhart1@us.army.mil) | Evaluation of biofidelic characteristics of synthetic tissue simulants | Gel samples sent from ARL to MIT for evaluation. Preliminary comparison between gel simulant and tissue properties show good fit to brain tissue behavior. Custom MIT testing tool for gel/tissue comparison is being retrofitted to perform at higher deformation rates (2011-12). |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|---------------------|--|--|---|
| N. Elman | WRAIR (David Lanar, david.lanar@us.army.mil) | Rapid Reconstitution Packages (RRPs) for malaria vaccine to provide support to deployed soldier without need for refrigeration or manual reconstitution | In 2010, CRADA for experimental tests of reconstitution of malaria vaccine developed at WRAIR. RRP prototypes to WRAIR for testing and follow-up optimization ongoing (2011). New prototypes being tested at WRAIR (2012) |
| N. Elman | SOCOM (M. Meyers, michael.meyers@socom.mil G. Mercer, Glenn.Mercer@socom.mil) NPS (A. Bordetsky, abordets@nps.edu) | Rapid Cortisol Probe as a portable unit to measure cortisol as a biomarker for physical stress of troops during training and deployment | Initiated collaboration with NPS for network-enabled system (2010). Interaction with SOCOM Human Performance to define specs & proposal for funding (2012). |
| M. Cima N. Elman | NPS (A. Bordetsky, abordets@nps.edu) SOCOM (M. Meyers, Michael.meyers@socom.mil , | Battlefield medical network integrated with biomedical micro-devices for increase in tactical medical support and situational awareness (UAVs, GPS, Radio) | Micro-structured prototype integrated in the NPS Tactical Network Topology (TNT) & battlefield medical scenario at Camp Roberts (cont. 2008-2012) |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--|---|--|--|
| M. Soljacic J. Joannopoulos Witricity, Corp. (K. Hall) | QinetiQ (Charlie Dean, Charlie.Dean@qinetiq-na.com). NSRDEC (K. Shukla, kailash.c.shukla.civ@mail.mil) | Efficient transport of electric power without use of wires. Elimination of inconvenience of cumbersome connecting wires on the Soldier's uniform | Investigating application of wireless, non-radiative resonant coupling method for transfer of electric power between power generators on the Soldier's torso and devices on the Soldier's helmet |
| P. Hammond G. Rutledge | NSRDEC (B. Kimball, brian.kimball@us.army.mil); D. Steeves, diane.m.steeves.civ@mail.mil) | Protective coatings on goggles and other military gear. | Transitioned the new layer-by-layer spraying technology unit (PADS Sprayer) from the ISN to NSRDEC (2010). Training provided by Svaya & ISN. Ongoing collaboration with Steeves on fabrication of PEM films. |
| M. Bawendi D. Nocera | ERDC-CERL-IL (A. Kumar, Ashok.Kumar@usace.army.mil ; L. Stephenson, larry.d.stephenson@usace.army.mil); | QD Sandwich assays for biological warfare agent sensing | Continue teamwork to transition ISN small QD mat's for use at CERL program |
| M. Bawendi D. Nocera | Invitrogen (now Life Technologies) | Biological applications of quantum dot technology | Licensed nearly all the QD technology related to biological applications |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|-------------------------------------|--|--|--|
| <p>T. M. Swager</p> | <p>FLIR Systems (formerly ICx) (Aimee Rose) Aimee.Rose@icxt.com</p> | <p>Iptycene containing dyes for enhance solubility in complex media</p> | <p>Dyes developed at MIT are an enabling technology in the FIDO-Paxpoint™ liquids explosive detector. 200 units are currently deployed in approximately 30 airports across the USA (2011-2012).</p> |
| <p>T. M. Swager Sgt. J. Cox</p> | <p>ECBC (Augustus W. Fountain III, augustus.w.fountain@us.army.mil)</p> | <p>Trace explosives detection using energy transfer schemes in electronic polymers</p> | <p>ECBC funded to assist in determining detection limit of sensors for ultra-trace detection of explosives and their constituents (2010). Limits of detection for cyclohexanone (explosives constituent) determined; device performance in presence of live C4 assessed. Joint ISN-ECBC paper for <i>Anal. Chem</i> to be submitted by early CY13.</p> |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|---|---|---|--|
| <p>T. Swager M. Boyce P. Hammond TSI (N. Rice, K. Mahmud)</p> | <p>ARL-WMRD (A. Hsieh, ahsieh@arl.army.mil) ECBC (C. Grove, corey.grove@us.army.mil)</p> | <p>Improved transparent poly(urethane-urea)s for face shield applications (e.g., enhanced mechanical strength, ductility, elasticity, and chemical barrier)</p> | <p>Improvements in both dynamic mechanical strengthening and barrier resistance against chloroethyl ethyl sulfide in transparent model PUU elastomers. Continued transitioning of triptycene chemistry research to ARL in-house program on design and synthesis of new PC copolymers.</p> |
| <p>D. Irvine</p> | <p>WRAIR (A. Yadava, anjali.yadava@us.army.mil); S. Dutta, sheetj.dutta@us.army.mil)</p> | <p>Delivery of malaria and other vaccines</p> | <p>Collaboration with WRAIR in develop & testing of innovative nanoparticle (ICMV) delivery of vaccines continuing: new CRADA to extend to <i>plasmodium falciparum</i> vaccine candidates being developed by S. Dutta; start-up to commercialize ICMV tech. for malaria vaccines being pursued.</p> |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--|--|--|---|
| P. Hammond Gr. Stephanopoulos A. Belcher | Ferrosan, Inc. (Flemming R. Jensen, frj@ferrosan.com) | Consumer healthcare and medical devices. Development of a surgical sponge (Surgifoam) with functionalized capabilities. | Under a sponsored research agreement, Hammond lab examined: coatings for release of hemostats (e.g. thrombin); delivery of other agents for wound healing applications including antibiotics and anti-inflammatories. |
| P. Hammond Gr. Stephanopoulos A. Belcher | WRAIR (D. Zurawski, daniel.v.zurawski@us.army.mil ; Capt. Kirkup) | Wound repair | Continued discussions re. use of Spray-LbL to deliver iron chelators as antibiotics for repair of orthopedic wounds. |
| I. Hunter T. Swager | Polymer Devices, Inc. (Priam Pillai, ppillai@mit.edu) | Manufacture & market conducting polymer based antenna products. | ISN startup company founded in 2010. Continuing transitions to develop products for defense, first-responder & commercial applications |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--------------------|--|---|--|
| <p>T. Palacios</p> | <p>ARL-SEDD (Dr. Madan Dubey, madan.dubey@us.army.mil)</p> | <p>Graphene growth and technology for high frequency and sensing applications</p> | <p>Beginning 2010: Help with set up of CVD graphene growth system at ARL; technology transfer to ARL of the graphene transfer technique and of the device fabrication.</p> <p>Graphene devices co-processing and joint simulation of graphene devices.</p> <p>Graphene film on sapphire samples delivered to ARL for sensing applications</p> <p>Currently working on a joint ARL-funded project on bilayer graphene devices</p> |
| <p>T. Palacios</p> | <p>ARL-SEDD (Dr. Madan Dubey, madan.dubey@us.army.mil)</p> | <p>MoS2 devices for high performance flexible and transparent electronics</p> | <p>Beginning 2012: Technology transfer for the fabrication and characterization of MoS2 devices at ARL.</p> |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|-------------|--|--|---|
| T. Palacios | NSRDEC (Dawn Nida, Dawn.Nida@us.army.mil, David Ziegler and Andre Senecal) | Chemical sensors to monitor food and water safety | FY11 6.1 and EAR Proposal on the study of the effects of novel biochemical modifications on the electrical properties of graphene |
| T. Palacios | ARL-SEDD (Dr. Matthew Ervin, Matthew.H.Ervin.Civ@Mail.mil) | Graphene-based ultra capacitors | Demonstration of a graphene-based ultra capacitor with state-of-the-art capacitance |
| T. Palacios | Triton Systems (Aniruddha Weling, aweling@tritonsys.com) | Graphene sensors for the detection of food-borne pathogens | Currently writing an SBIR proposal together to commercialize the sensors developed under ISN-2 |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|-----------|--|--|--|
| M. Strano | NSRDEC (Richard M. Osgood, richard.m.osgood@us.army.mil) | Optical antenna structures and RF components | ISN expanded graphite samples sent to NSRDEC for electro-optical characterization, and awaiting further analysis. |
| M Strano | NSRDEC (Dawn L. Nida, Dawn.Nida@us.army.mi) | Novel sensor systems | Development of chemical printing and deposition on graphene structures for sensor purposes. Several NSRDEC team visits to Strano lab for use of his advanced lab facilities. |
| M. Strano | ERDC CERL (C.R. Welch, Charles.R.Welch@usace.army.mil; C. Marsh, Charles.P.Marsh@usace.army.mil) | Stronger, lighter weight materials through ultra-long single wall CNTs | Development of micro-nano carbon fiber growth, leading to a joint publication. Continued collaboration extended to new nanostructured film work (i.e. chainmaille concepts) and conducting composites. |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|--|--|--|---|
| <p>K. J. Van Vliet Z. I. Kalcioglu R. Mahmoodian A. K. Adityan</p> | <p>ARL-WMRD (M. VanLandingham, mark.vanlandingham@us.army.mil ; J. Lenhart, joseph.lenhart1@us.amrmy.mil; Randy Mrozek, randy.a.mrozek.civ@mail.mil)</p> | <p>Design of isotropic tissue simulants as predictors of soft-tissue high-strain rate impact trauma</p> | <p>Completed nanomechanical impact analysis of polymer gels synthesized by Randy Mrozek, using instrumented impact indentation developed for tissue simulants; now employing computational tools for studying a wider range of polymer gels at higher strain rates.</p> |
| <p>K. J. Van Vliet Z. I. Kalcioglu R. Mahmoodian</p> | <p>ARL-WMRD (M. VanLandingham, mark.vanlandingham@us.army.mil ; J. Lenhart, joseph.lenhart1@us.amrmy.mil; Randy Mrozek, randy.a.mrozek.civ@mail.mil)</p> | <p>Distinguishing between the viscoelastic and poroelastic regimes; Characterization of poroelastic behavior of gels and tissues for tissue simulant purposes.</p> | <p>Designed, completed and analyzed experiments for establishing a contact-based method for the microscale characterization of poroelastic materials, within seconds as opposed to hours required at the macroscale.</p> |

2011-2012 ISN-2 Research Transitions

| Performer | Customer | Application | Result |
|---|---|--|---|
| <p>B. Wardle S. Socrate</p> | <p>US Army ERDC-CERL (Ashok Kumar, ashok.kumar@usace.army.mil, Jonathan Trovillion jonathan.c.trovillion@usace.army.mil)</p> | <p>Hierarchical Nano-Engineered 3D Advanced Composites for Survivability</p> | <p>MIT provided laminate level 3D nanoengineered composite materials for ballistic impact resistance testing at ERDC-CERL (2011-2012)</p> |
| <p>I. Hunter T. Swager E. Paster P. Pillai (PD,Inc)</p> | <p>ARL-SEDD (Steven Weiss, steven.j.weiss14.civ@mail.mil)</p> <p>CERDEC QRC (Brent Christensen, brent.d.christensen.civ@mail.mil)</p> <p>NSRDEC QRC (David Roy, david.f.roy.civ@mail.mil)</p> | <p>Conducting polymers for SOCOM SATCOM rucksack conformal antenna.</p> | <p>A Quadloop antenna, a 4-element fan dipole, a J-Fed half wave antenna, and a Meander line monopole antenna made from conducting poly-mers were tested at Weiss's lab in 2011. Tests indicate low gain values with good directionality. Follow on steps to improve gain and return loss on-going. Continuing: with ARL verified design improvements from changing size and type of radiating element pattern.</p> |

2011-2012 Outreach & Metrics

- **Interest from Senior Army / DoD Leadership**

- **4 General Officer Visits**

- *Defense Science Board Summer Studies Group Aug2012; Director, Strategic Planning Office, ODASA(R&T) Jul2012; Chief, Human Dimension Task Force, ARCIC Jul2012; CSA Strategic Studies Group Jul2012; Commander, Navy Medicine East/ Commander, Naval Medical Center Portsmouth/ Chief, Navy Dental Corps Jun2012; Director, National Intrepid Center of Excellence for TBI and PTSD, Jun2012; Soldier Portfolio Director, ODASA(R&T) Jun2012; Director, Army Research Laboratory June2012; Director, Natick Soldier RDEC Jun2012; Deputy Principal Assistant for Research and Technology, MRMC Jun2012; Director, SORDAC(S&T) May2012; Director, Combat Casualty Care Research Program Apr2012; Chief Science Advisor, Combatting Terrorism Technical Support Office Apr2012; Chief Scientist, US Army Apr2012; Sergeant Major, Army Research Laboratory Apr2012; Command Sergeant Major, RDECOM Apr2012; Director, Army Research Laboratory Apr2012; Director, NSRDEC Apr2012; Director, RDECOM Apr2012; Principal Military Deputy, OASA(ALT)/Chief, Army Acquisition Corps Apr2012; Secretary of the Army Mar2012; DASA(R&T) Mar2012; CG, ATEC Feb2012; PEO-Soldier Nov2011; Deputy PEO-Soldier Nov2011; Director, IARPA Oct2011*

2011-2012 Outreach & Metrics

- **Visits from Other Military Branches and Allies:**

Defense Science Board; Navy Medicine; Technical Research and Development Institute, Japanese Ministry of Defense; Ministry of Science, Technology, and Innovative Production, Argentina; SOCOM-SORDAC(S&T), Deployed War-Fighter Protection Program; USAF Medical Service; Swedish Defense Materiel Administration, Australian Department of Defence; IARPA

- ~ **over 600** Visitors since 2011 TAB

- **Participation in Trips**

NSRDEC, ARL-WMRD, ARL-SEDD, ARL-CISD Aberdeen, ARL-CISD Adelphi, ECBC, DTRA, ERDC-CERL, AMRDEC, NPS, Camp Roberts, MPMC, WRAIR, UARC & FFRDC Directors Mtg., The Pentagon, RDECOM, Ft. Belvoir, AFOSR Spring Review

2011-2012 Outreach & Metrics

- **ISN Thematic Workshops**

Army/ISN/ICB (TBI Cognitive Dimensions)

- **ISN Monthly Seminar Series (ANTS)**

Accessible to off-site colleagues by webcasting. Speakers typically come from Army Labs, Industry, and Academia. Schedule to be posted at:

<http://web.mit.edu/isn/newsandevents/ants2012-2013.html>

- **ISN-Army-Industry Collaboration Conference**

A biennial event designed to showcase current ISN collaborations with Army and Industry colleagues, and to nurture and initiate new collaborative efforts. The ISN-AICC was recently held on June 20, 2012, and attracted nearly 150 attendees. The next ISN-AICC will be in 2014.

- **ISN-ArmyLabs Student/Post-Doc Research Innovation Symposium**

A biennial event to showcase the innovative research performed by ISN students /post-docs and Army research scientists & promote further collaborations. The next IAL-SPRIS is scheduled for June 19, 2013.

2011-2012 Outreach & Metrics

- **Industrial Coordination Committee (ICC)**

Facilitate regular & substantive ISN-Industry-Army interactions & collaboration. Co-Directors R. Radovitzky (ISN) & M. VanLandingham (ARL-WMRD). Annual meetings typically in January. The next ICC meeting is planned for early 2013.

- **Army-ISN Facilities Intranet**

Leverage extensive specialized Army testing & characterization facilities for use by ISN researchers: in collaboration with NSRDEC & ARL-WMRD.

<https://isn.mit.edu/labs/armyequipment.php>

- **Army HPC System Access**

Enable ISN researchers to utilize the vast capabilities of Army Research Laboratory's DoD Supercomputing Resource Center

- **ISN Summer Research for USMA Cadets Program**

Dovetails with the USMA Advanced Individual Academic Development (AIAD) Program. Each summer, the ISN welcomes cadets from the USMA Department of Systems Engineering who engage in short-term goal-oriented research projects. ISN Coordinator K. Keville. Summer 2012, ISN hosted two cadets.

2011-2012 Outreach & Metrics

- **ISN-Army Labs Summer Internship Program**

Initiated March 2008, MIT undergraduates perform research at Army Lab facilities during the summer. Co-invest to cover salary (Army Labs) and living expenses (ISN). Ms. Marlisha McDaniels of the ISN Headquarters team is program coordinator. Online system allows Army personnel to post internship opportunities & students to post CVs. Summer 2012, nine MIT students were selected for internships at four Army research facilities

- **HBCU-MI Program**

Fund basic research projects at HBCU-MI partner institutions and provide opportunities for HBCU-MI students to participate in ISN related projects. ISN Coordinator Prof. P. Hammond, with assistance from M. McDaniels.

- **ISN Soldier Design Competition (SDC)** – Annual event. Finals of SDC10 set for April 4, 2013



Annual ISN Soldier Design Competition



- Introduce MIT students to DoD research (& help build US S&T pool)
- Unite MIT and West Point communities
- Invent new technology to address REAL Warfighter problems
- Encourage transitioning & commercialization

TEAM EFFORT: supported through Industry, MIT, Army/Marine mentors, and Army/ARL/ARO-funded ISN staff and students



communications





A Sampling of Previous SDC Winners



Year IX (2012)

1st Place: \$5,000
 MIT
Medical Diagnosis App for the Soldier in the Field



Year II (2005)

2nd Place: \$3,000
 MIT
Powered Rope Ascender

lifts 350lbs, 50ft in 10sec



Year VIII (2011)

1st Place: \$5,000
 USMA
Modified HESCO Barriers for Rapid Deployment

NSRDEC & ERDC interest
Evaluation & live fire testing at JRTC Ft. Polk in late 2011



2009 REF shipping units into OEF for Marines.
Demo'd at Fleet Week 2010.
Many funding sources...

Year VII (2010)

2nd Place: \$3,000
 MIT
Soldier-Uniform Conducting Polymer Conformal Antenna

PolymerDevices, Inc.
ARL / NSRDEC / CERDEC Interest in novel antenna applications for the Soldier

Year I (2004)

2nd Place: \$3,000
 MIT
Hand/Arm Com Signal Translating System



Summary

Nanotechnology-Enabled Enhanced Survivability for the Soldier by Exploiting:

- ***Synergistic MIT, Army, Industry Partnership***
- ***Innovative Cutting-edge 6.1 Research Portfolio
to Help Identify “Revolutionary” Opportunities***