Research and Services Capabilities at Fayetteville State University

Daryush ILA, Ph.D.
Associate Vice Chancellor for Research & TTO
FSU Background (I)

- Established 155 years ago
- Nearly 6200 students
- All programs are accredited by SACS
- Forensics degree, training/services
- Intelligence Study degree program
- Top ranked SBE (SSRN network)

http://www.ssrn.com/institutes/top_institutions_transfer_files/top_institutions_transfer_files.htm
FSU Background (II)

- Criminal Justice degree program
  (Certified by academy criminal justice science)
- Advanced degrees in computer sciences, Chemistry, Physics, Biology and Chemistry with Materials track
- 3/2 Engineering program with NCSU;
  - Chemical Engineering,
  - Computer Engineering,
  - Electrical Engineering, and
  - Civil Engineering
Core Facility

Focus Area:

Research and Development services
- Materials Characterization,
- Imaging,
- Synthesis, &
- Analytical Chemistry

Project Description:
To provide state-of-the-art capabilities for FSU and the local community in support of cutting-edge research, transformative hands-on education, and technical development.

http://www.uncfsu.edu/research/core-facility-initiative

Current Projects/Sponsors:
- DOD, DoEd, NSF, Industries, State, FSU
- FSU Departments of:
  - Chemistry
  - Physics
  - Biology
  - Computer Science
  - Research

Major Available Instrumentation:

Collaborations:
- US Department of Education
- National Science Foundation
- Department of Defense
- Industries
- Universities

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**Prototyping Lab**

**Inventor Space**

*Where Imagination Becomes Reality*

**Description**

To provide. Outlets Inventions, for both On-campus and Off-Campus Visionaries

- Space
- Equipment
- Facilities
- Expertise

**Current Projects**

- Agro-tiling for extreme environment
- Medical Devices
- Nanocrystal production & applications
- Thermoelectric Devices & applications
- Pollution Remediation
- Green pest control
- Laser - Propulsion and attitude control

**Collaborations**

- Inventors/Visionaries
- Small Businesses
- Federal Agencies
- US Army Research Lab
- US Army Med. Command
- Industry

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http://www.uncfsu.edu/research/prototyping-validation-and-verification-initiative
Innovation & Technology Transfer

Focus Areas
- Innovation & Invention
- Patenting (IP)
- Technology Transfer
- Start-ups
- Commercialization
- Licensing

Description
To provide outlets for Innovation and Inventions through Intellectual Property Protection (Patents, Copyrights & etc.), Technology Transfer (Commercialization and Licensing) and promoting University Start-ups.

Current Patents:
- Silica-Based Plant Growth Medium (2 patents)
- Novel Wound Care Recovery Device
- Pest Control Composition
- Energy conversion (Heat to Electricity)

Current Projects/Sponsors
- Innovation Fund NC
- iMatSci
- Fayetteville State University
- Industry
- Others

Current Start-ups
Next Generation Biomedical LLC, ……..

Collaborative Research Ideas/Potential Sponsors
- Industry
- Department of Energy
- Department of Defense
- National Science Foundation
- Department of Education
- Universities
- Small Businesses

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http://www.uncfsu.edu/research/innovation-and-technology-transfer
Market Readiness Level (FSU tool)

- **Device is at the Market** → 20
- **Scale up** → 16
- **Prototype Developed** → “Similar to SBIR III!” → 12
  - **Advanced in Development** → “Similar to SBIR II”
  - **Maybe ready for SBIR(1) or PFI**
  - **Proof of concept** → “I have data to prove my idea” → 8
  - **Develop theory, instrument and Collect data for proof of concept**
  - **Idea in thought state** → “I think, so I am” → 4
  - **1**
Mentor Protégé
Services at Fayetteville State University

Focus Area

FSU provides a wealth of information technology services and solutions, computer & communications systems knowledge, network software and testing expertise, and various technical training to satisfy a protégé firm’s technical requirements.

Description

• Assist small & disadvantage businesses
• Enhance small business’ technical capabilities and business acumen
• Enable small businesses to successfully compete for government contracts and subcontracts
• Provide certified on-line and onsite training anywhere and anytime
• Tailor the courses to specific needs of the protégé
• Help you find a mentor, and coordinate with your program manager to set up program

Current Projects/Sponsors

• Cognition, LLC; RLM Communications, INC; Department of Defense; Prodigy Capital Consulting Group; NSK Security Management Solutions; Department of Homeland Security; United States Army; Lockheed Martin; Air Force Associates; K3 Enterprises
• List of past and present partners

Collaborative Research Ideas/
Potential Sponsors

• SBA – Mentor Protégé
• DOD – Mentor Protégé
• NASA – Mentor Protégé
• SWOT analysis – DOD M&P
• Strategic planning and Business Development support --- SBA

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http://www.uncfsu.edu/research/mentor/prot%C3%A9g%C3%A9
The Center for Defense and Homeland Security (CDHS)

- **Develop** the next generation workforce professionals for:
  - National Security Challenges
  - Cyber Security
  - Disaster preparedness
  - STEM

- **FOCUS Areas:**
  - Intelligence studies
  - Geospatial Intelligence
  - Cyber Security
  - Analysis

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www.uncfsu.edu/cdhs
Focus Area

- The SENCR-MIC provides state-of-the-art microanalytical and imaging capabilities.
- Cutting-edge research in Materials Science, Physics, Chemistry, Geoscience, Life Science, Engineering and so on.
- Transformative STEM education to students for hands-on research experiences.
- Forensic investigations by users from federal governmental agencies.
- Technical development to support local and nationwide industrial users.

Current Projects/Sponsors

- FSU major users: Drs. Zhiping Luo, Shubo Han, Daryush Ila, Cevdet Akbay, Alexander Umantsev, Khalid Lodhi, Lieceng Zhu.

Description

- The SENCR-MIC is an open platform to conduct sample structural characterizations, funded by the U.S. Army Research Office.
- The SENCR-MIC is open for guided tours and demonstrations on an as needed basis.
- SENCR-MIC houses state-of-the-art JEOL 8530F Electron Probe Microanalyzer (EPMA) with field-emission source (the only one in NC and surrounding states), JEOL 6510LV SEM, Agilent 5500 AFM/SPM, Rigaku MiniFlex 600 XRD, light microscopes with CCD cameras, and completed sample preparation equipment.

Collaborative Research Ideas/Potential Sponsors

- The mechanical injection method can prepare vertically aligned nanowires with lower melting points below 650 °C.
- Collaborations are needed to use different strategies to prepare nanowires with higher melting points.
- Potential sponsors: NSF, DoD, NRC.

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Focus Area

Through online courses, workshops, seminars and conferences, FSU online courses will help you increase your progress toward graduation, prepare for a new career, advance within your current profession, learn new skills and improved your quality of life.

Typical Students

- FSU employees
- Freelance or consultants
- Single student seeking national certification training
- Those seeking new career paths
- Military
- Displaced workers
- WIA

Description

Students who enroll in JER Online courses are either individuals, employees of a company, consultants and freelancers or those seeking new career choices. Start anytime or on a fixed time schedule and access your course anytime from anywhere for fast completion.

Collaborations

- Fayetteville State University with
- US Army and
- Industries

Contact Information

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THANK YOU!

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Over three dozen MPP contracts and seven years in a row received eighteen Nunn-Perry Awards
Sample portfolio (Actual)

- First ten years (Conservatively)
- Second ten years (forecasted)
Other Relevant Research

Surface and interface engineering (adhesion, thermal cycling, electrical, optical, thermoelectric, thermo-luminescence, thermal signature, hydrogen embrittlement, hydrogen sensing, …)
**Carbon Composites and GPC**

GPC is high temperature materials, ultralight high strength composites

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Density</td>
<td>Mg/m³</td>
<td>1.3 – 1.5</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>MPa</td>
<td>40 – 100</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>MPa</td>
<td>210 – 260</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>MPa</td>
<td>480 – 580</td>
</tr>
<tr>
<td>Young's Modulus</td>
<td>GPa</td>
<td>14 – 33</td>
</tr>
<tr>
<td>Gas Permeability</td>
<td>mm²/s</td>
<td>10⁻⁴ – 10⁻¹⁰</td>
</tr>
<tr>
<td>Vickers Hardness</td>
<td>HV1</td>
<td>230 – 340</td>
</tr>
<tr>
<td>Thermal Expansion</td>
<td>1/K</td>
<td>~ 10⁻⁸ (can be &lt;0)</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>W/Km</td>
<td>0.238 – 1.428</td>
</tr>
<tr>
<td>Electrical Resistivity</td>
<td>ohm·m</td>
<td>10 – 50 x 10⁻⁶</td>
</tr>
</tbody>
</table>

Induction heated, in air, repeatedly, to as high as 2400 K, for several hours. Tube OD is 16mm. The maximum thermal gradient is over 200K / mm, possible because of the small thermal expansion and large strain to failure for GPC.

Holland, Jenkins, ILA, Evelyn, Zimmerman, Chhay, Maleki, and Fisher
Enhanced hardness & Controlled stiffness

Stress-strain of GPC with various concentrations of CNT in the GPC matrix. The more CNT added, the stiffer composite is.

Stress-strain curve of GPC and GPC composites. When nanopowder is added in the GPC matrix, composites material withstand more stress before fracture.

Chhay, ILA, and Zimmerman
Thermoelectric Research

Conformal, ultra-light, high volume fraction nanomaterials and highest ZT reported.

\[ ZT = \frac{S^2 \sigma T}{\kappa} \]

ILA, et al TEM work as of 2016

Present State of Art

<table>
<thead>
<tr>
<th>Materials</th>
<th>Reported ZT/Temp</th>
<th>UNCFSU ZT/Temp</th>
<th>Potential ZT/Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂Au/SiO₂</td>
<td>0</td>
<td>2.52 @ 360K</td>
<td>&gt; 2.52</td>
</tr>
<tr>
<td>Bi₄Te₃/Sb₂Te₃</td>
<td>1.1 @ 350K</td>
<td>2.6 @ 350K</td>
<td>&gt; 2.6</td>
</tr>
<tr>
<td>SiO₂Ag/SiO₂</td>
<td>0</td>
<td>0.085 @ 300K</td>
<td>&gt; 0.7</td>
</tr>
<tr>
<td>Zn₃Sb₃</td>
<td>0.50 @ 300K</td>
<td>0.53 @ 300K</td>
<td>Under Investigation</td>
</tr>
<tr>
<td>CeFe₂Co₂Sb₁₂</td>
<td>0.05 @ 300K</td>
<td>3.07 @ 300K</td>
<td>&gt;3.5</td>
</tr>
<tr>
<td>SiO₂Ag/SiO₂Au &amp; SiO₂Au</td>
<td>Patent</td>
<td>3.4 @ 300K 3.88 @ 500K</td>
<td>&gt; 3.8 &gt; 3.65</td>
</tr>
<tr>
<td>Si₁ₓGeₓ/Si</td>
<td>0 @ 300K 0.6 @ 1200K</td>
<td>0.61 @ 300K</td>
<td>&gt;&gt; 0.61</td>
</tr>
</tbody>
</table>

TEM in the market: Efficiency < 17%

Our TEM (Work): Efficiency > 25% (25-30%)

Operational Temp >100°C (mostly) vs. 27°C to 900°C

Bulk (lowest efficiency), Mol. Beam Epitaxy/MBE (expensive) vs. Coating on any surface (Inexpensive and conformal)

Working in series (mostly) vs. Works in parallel (tough)

Radiation sensitive (mostly) vs. Radiation resistant (mostly)

ILA, Zimmerman, and Zheng
Controlled Fabrication of Micro-/Nano-pores Membranes

Production of nanopores in Fluoropolymer films

Nano pore production for single molecule biochemistry DNA and Protein characterization

Perfluoroalkoxyethylene (PFA) $[\text{CF}_2\text{CF}_2]_{0.99}[\text{CF}_2\text{COF}_3]_{0.01}$