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Beyond Novel Materials

S&T Campaign: Materials Research

Tier 2 Subtopics: Photonics, Electronics, and Manufacturing Science

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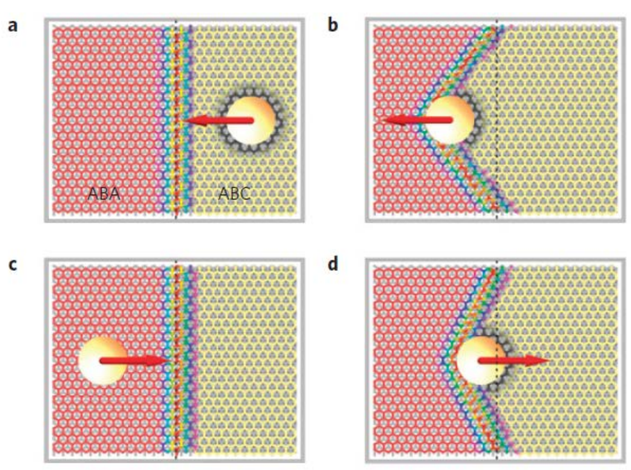
Research Objective

- Discover, design and develop future materials to meet the demands of a transforming battlefield
- Army requires lower power, more energy efficient, lighter weight operations that maintain/enhance lethality and survivability while reducing logistics trail

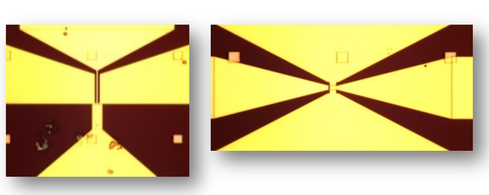
- **Impact:** Ultra-low power, flexible electronics/comms., enhanced energy harvesting and full spectrum threat sensing in extreme environments; Lighter more lethal systems enable mobile protected firepower systems which are faster, more efficient and enhance our strategic maneuver capability.



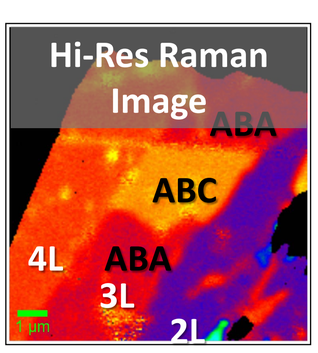
Electric field tuning of trilayer graphene stacking phase orientation via electric field

Challenges

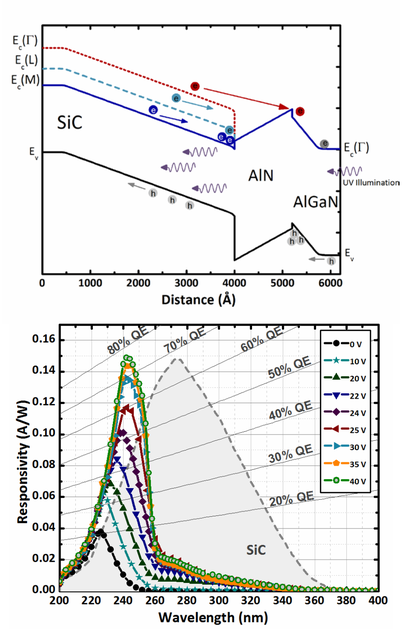
- Topological materials such as narrow gap semiconductors HgCdTe QWs, InAsSb, and interface to High Tc Superconductors
- Polarization-enhanced/switchable topological narrow gap semiconductors such as InN/GaN superlattices
- Bio/non-bio interfaces and hybrid bio-metal topolological insulators: oligopeptide-metal complexes
- Van der Waals heterostructures (2D-3D electronics)
- Highly mismatched/polarization enhanced alloys/heterostructures at solid/liquid interfaces for energy scavenging
- Coupling of high energy/ultrafast fields to matter to create new phases and properties



DC and RF FETs on 2D materials



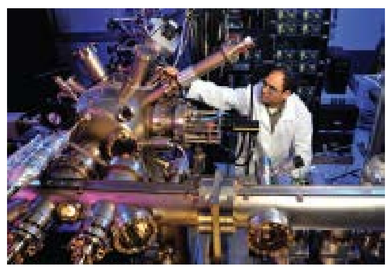
Raman microscopy of 2D materials



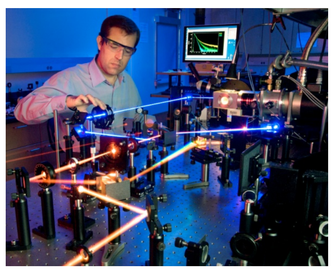
III-N/SiC Polarization-Enhanced UV Detectors

ARL Facilities and Capabilities Available to Support Collaborative Research

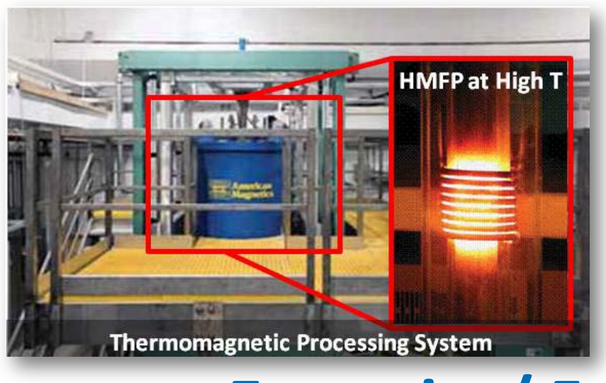
- Expertise in growth:
  - Narrow bandgap III-V, II-VI, III-IV-VI, and High Tc superconductors for topological materials studies and devices
  - Polarization-enhanced III-N/SiC materials and devices
  - Highly mismatched III-V-N-Sb/As alloys and heterostructures
  - Graphene and transition metal dichalcogenides, and 2D device fabrication
- Characterization: Ultrafast spectroscopy of UV, Vis, IR, and THz materials and devices; Raman microscopy of 2D materials
- Facilities
  - III-V As/Sb, III-V-N, III-V-N-As/Sb, II-VI, III-IV-VI molecular beam epitaxy growth reactors
  - III-V-N and High Tc superconductor MOCVD and graphene/2D materials growth reactors
  - Ultrafast spectroscopy facility with tunability from < 200 nm to > 10000 nm for time-resolved materials studies spanning fs to CW
  - Ultrasonic Additive Manufacturing (UAM)
  - Thermomagnetic Processing System (9T ;8” bore; 2200oC)
  - 2.45 GHz and 915 MHz Single Mode Microwave Sintering Systems (2000oC; 3,000 psi)



Molecular Beam Epitaxial growth



Ultrafast Spectroscopy



Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

Seeking collaboration in materials genome modeling, multiscale modeling from materials to devices, physics studies of new materials and devices, fundamental understanding of ECM phenomenon, ECM modeling & simulation of field-material interactions, and extreme field facilities

ALC tour stops: Specialty Electronic Materials and Sensors Cleanroom (SEMASC) (ALC, Z3) & III-Nitride Materials Growth (Z3B-15), Ultrafast spectroscopy facility, and Nanoelectronics (Z2D-34)

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