Establishing a Center of Excellence for
Security Science and Engineering

Ke-Xun (Kevin) Sun, Ph.D, P.E.

Department of Electrical and Computer Engineering
University of Nevada, Las Vegas
&
North Las Vegas & Livermore Operations
National Security Technologies
Outline

• Introduction
• Progress report
• NNSA proposal to establish Center of Excellence for Security Science and Engineering
• Perspective on UNLV-NSTec collaboration
UNLV Center of Excellence for Security Science and Engineering

- Multiple step process:
  - Individual faculty who are interested in security science and engineering
  - NSTec station at UNLV
  - NSTec-UNLV Center of Excellence for Security Science and Technologies

- Center of Excellence in Security Science and Technologies
  - Rotational faculty and student projects
  - Resident researcher team
  - Secured R&D facility on campus to enable NSTec projects
  - Respond to large BAA
  - User facility, or equivalent coordination
  - Ramp up in 3~5 years

Education Value Meets NSTec Staffing Needs

- Graduate students
  - Term projects
  - Master theses
  - Ph.D theses

- Undergraduate students
  - Term projects
  - Undergraduate theses

- Internship
  - Regular academic quarters
  - Summer off-campus
Gain External Funding

- Win large BAA
  - Need critical project and academic credentials
  - Need strong team from NSTec and UNLV
- Win large program
  - Need BAA credential
- Center of Excellence for Security Science and Engineering
  - Becomes a research center of security sciences and technologies
  - Becomes a user facility

Good Progress!
Proposal to NNSA Stockpile Stewardship Academic Alliance

Enabling Sciences and Technologies for Next Generation HEDP Diagnostics

Ke-Xun (Kevin) Sun, Ph.D., P.E.
Lead Principal Investigator
Professor, Department of Electrical and Computer Engineering
University of Nevada, Las Vegas (UNLV)

and

Senior Scientist, Defense Experimentation and Stockpile Stewardship Division
National Security Technologies (NSTec)

Co-Investigators

William Culbreth Professor of Mechanical Engineering
Biswajit Das Professor of Electrical and Computer Engineering
Yingtao Jiang Associate Professor of Electrical and Computer Engineering
Pushkin Kachroo Professor of Electrical and Computer Engineering
Eunja Kim Assistant Professor of Physics
Brendon O’Toole, Professor of Mechanical Engineering
Tao Pang Professor of Physics
Emma Regentova Professor of Electrical and Computer Engineering
Robert Schill Professor of Electrical and Computer Engineering
Mohamed Trabia Professor and Associate Dean of College of Engineering
Rama Venkat Professor of Dean of College of Engineering
Woosoon Yim Professor of Mechanical Engineering

University of Nevada, Las Vegas
Research and Development Areas
Focusing on “Platform” Technologies for
Future NIF High Yield Experiments and LIFE

1. Radiation hardness mechanism studies
2. Radiation hard GaN-AIGaN-AlInGaN devices and systems
   - Electronics
   - Optoelectronics
   - Imagers
3. Radiation detection, especially exploration of alternative approaches
4. Plasma sciences and radiation sources
5. Radiation hard robotics systems for unmanned safe operation
6. Computational physics and image analysis.
UNLV Faculty Contributions (I)

- Radiation Hard GaN-AlGaN-AllInGaN Devices and Systems
  - Kevin Sun: GaN Devices & Imagers
  - BJ Das: GaN Growth and Devices
  - Yingtao Jiang: Integrated circuits, Imagers
  - Eunja Kim: GaN Theory
  - Bob Schill: Pulsed Power, Nevada Shocker
  - Rama Venkat: Processing model

- Radiation detection
  - Kevin Sun: GaN Optical readouts,
  - Bob Schill: EM DOT
  - NSTec: Neutron Tracking

- Plasma Sciences and Radiation Sources
  - Bob Schill: DPF, Pinch, X-ray source
  - Kevin Sun: Nanomaterial Enhanced X-ray sources
UNLV Faculty Contributions (II)

• Radiation hard mechanical materials and robotics
  – Mohamed Trabia: Material Strength
  – Brendan O’Toole: Neutron Irradiation Effects
  – Woosoon Yim: Robotics
  – Kevin Sun: Machine vision materials

• Computational physics and data analysis
  – Pushkin Kachroo: Inverse scattering, MHD theory
  – Emma Regentova: Image analysis
  – Tao Pang: Dynamic Space Charge Effects (Theory)
  – Eunja Kim: Dynamic Space Charge Effects (Computation)
  – Kevin Sun: Dynamic Space Charge Experiments
Why Radiation Hard Detectors

• The current “Rad-Hard” mitigation are films, requiring replacements every shot
  – Radiation hazard for film workers
  – In-efficiency
  – Low performance
• The proposed Radiation Hard semiconductor detectors will work as permanent sensors
  – Long term needs by LIFE and spent fuel re-use
  – No radiation hazard by eliminating film operations
  – Efficiency with real-time data access
  – High performance
DT Fusion and Neutron Fluence Estimate at National Ignition Facility (NIF)

- Ignition shot: $N \sim 10^{15}$ neutrons
- Neutron energy $\sim 15$ MeV
- Detector placed at 1 m away from target
- Neutron emission per ignition shot $\sim 10^{15}$
- Fluence at 1 m away

$$F = \frac{N}{4\pi R^2} \approx 8 \times 10^9 \text{ 1/cm}^2$$

- One year fluence (700 shots)
  $$F_{\text{year}} \approx 5.6 \times 10^{12} \text{ 1/cm}^2$$
- Proton irradiation test fluence
  $$F_{\text{test}} \approx (1 - 5) \times 10^{12} \text{ 1/cm}^2$$
Irradiation Configuration

- Proton beam
- Aperture
- UV illumination
- UV LED central wavelength 255 nm
- Operating current 5.26 mA
- ON/OFF control by power supply

Photodiode Readout

Nevada National Security Site
Managed and Operated by National Security Technologies, LLC
Vision – Service – Partnership
AlGaN UV Photodiode Radiation Hardness Test at 65 MeV Proton Beam Facility

Work at National Security Technologies, LLC is done under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy with the U.S. Department of Energy. DOE/NV/25946--1221

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UV LED Radiation Hardness Using Proton Irradiation

UC Davis proton energy:
59 MeV for 80 pA & 500 pA
63.8 MeV for 15,000 pA

Space proton energy:
2~5 MeV

Total fluence: > 100 year proton fluence in LISA orbit

Reference for proton test of other LED and laser diodes:

Sun, Leindecker, et al, “UV LED Qualification for Space Flight”,
AlGaN Photodiode UV Light Response vs. Proton Fluence

- Photodiode in photovoltaic mode
- For each fluence level, measure the photodiode readout for UV light on and off
- The normalized differential reading is defined as the photodiode response to UV light

AlGaN Detector Arrays
AlGaN Imager: NSTec SDRD FY12

- Photodiode Arrays
  - 2x2 array initial test design
  - Center wavelength 255 nm
  - 2 working batches received (!)
RadOptics Sensor

PZT Trace (Displacement ~ 1.8 \( \mu \text{m} \))

Interferometer output 632 nm

GaN Laser 405 nm

HeNe Laser 632 nm

Stage driven

PZT driven

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UNLV-NSTec SDRD February 2012
Steps to grow UNLV-NSTec Collaborations

• Pilot projects
  – Individual PI collaboration
  – Sun and others
• NSTec seed funding
• Gain External funding
• A NSTec-UNLV Center of Excellence in security science and engineering
  – An collaborative research center
  – A user facility
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