

Two-Dimensional (2D) Layered Based Nanotechnology

Dimitris Pavlidis

National Science Foundation, Division of Electrical
Communications and Cyber Systems / Electronics, Photonics
and Magnetic Devices, Arlington VA 22230
dpavlidi@nsf.gov

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Outline

- **Introduction and Motivation**
- **Growth considerations**
- **Device Concepts**
- **Project Examples**
- **NSF and other investments**
- **Conclusions**

Growth efforts: toward a 2D Infrastructure and Reproducibility

EFRI 2-DARE: 2D Crystals formed by Activated Atomic Layer Deposition

**Joan Redwing et al
Penn State**

Toward 2D-CMOS Hetero-Integration

Jim Hwang

jh00@lehigh.edu



Steep Slope Transistors Based on 2D MoS₂ and the Electronic Phase Transition in VO₂

B. Grisafe, N. Shukla, M. Jerry, **S. Datta**
University of Notre Dame,



ELECTRONICS, PHOTONICS, AND MAGNETICS DEVICES (EPMD) : CURRENT TOPICS

Electronics: Dimitris Pavlidis

- Microwave/mm-Wave/THz Devices & Components
- Nanoelectronics & Next Generation Devices, Semiconductor Material - Device Interaction, Reproducible Technologies and Reliability
- Wide/Extreme- and Narrow-Bandgap including 2D Semiconductors and Devices, Circuits, Device/Circuit Simulation & Modeling
- Device related Electromagnetic Effects, Propagation and Scattering
- Metamaterial and Plasmonic-Based Devices &

Magnetics: Usha Varshney

- Bioelectronic and Biomagnetic Devices
- Magnetics, Spin Electronics and Quantum Devices
- Sensor Device Technologies
- Next Generation Logic and Memories
- Paper Electronics
- Silk Electronics
- Reconfigurable Electronics

Solar: Nadia El-Masry

- Flexible, Printed and Organic Electronics & Photonics
- Organic and hybrid Photovoltaic solar cells
- Carbon-based Electronics
- Beyond Graphene 2D Materials and Devices
- Nano-electronics and Energy-Efficient Electronics
- Solar Cells & Photovoltaic Components including Low cost and high efficiency tandem solar cells

Photonics:

D. Dagenais & J. Zavada

- Advanced Optical Sources & Photo-detectors
- Nanophotonics, plasmonic & metamaterials
- Photonic Integrated Circuits
- Nonlinear & Ultrafast optics
- Quantum photonic devices
- Optical Sensing & Imaging
- Optical communication



EFRI (EMERGING FRONTIERS IN RESEARCH AND INNOVATION)

Mandate: Serve a critical role in helping the Directorate for Engineering focus on important emerging areas in a timely manner (began in 2007).

Community Driven: Engages the research community (through DCL) and ENG/NSF PDs to identify and fund a portfolio of projects in strategic emerging interdisciplinary areas that may not be supported with current NSF programs and in which ENG researchers play the leading role.

Criteria: Potentially transformative, high-risk / high-reward, and interdisciplinary topics

Budget: Mid-scale project funding mechanism in ENG (\$2M over 4-years)

Recent EFRI Topic on 2-D materials

FY2014-15: 2-Dimensional Atomic-Layer Research and Engineering (2-DARE)

- **20 awards with \$40M total funding, multi-institutional research**

<http://www.nsf.gov/div/index.jsp?div=EFMA>

CONCLUSIONS

- 2-D materials can potentially impact multiple disciplines and provide new enabling technologies for Electronics and Photonics,
- Strong need to address various applied aspects: Devices with unique properties, Defect reduction, Reliability, Reproducibility
- Worldwide investment made on fundamental 2D research
- **Novel 2D devices are expected with proven uniqueness compared to the other technologies**

THANK YOU!

