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# **AMMTO Peer Review**

## **Subprogram Overview**

### **Semiconductors (Micro- and Power Electronics) Manufacturing**

***“for Earth, for Country and for AMMTO”***

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# Key Definitions

- “Semi” conductors are materials that only conduct electricity when energy is applied to them.
- In this presentation, a semiconductor is a material that is part of a solid-state electronic device.

## Power Electronics\* vs. Micro- & Other Electronics

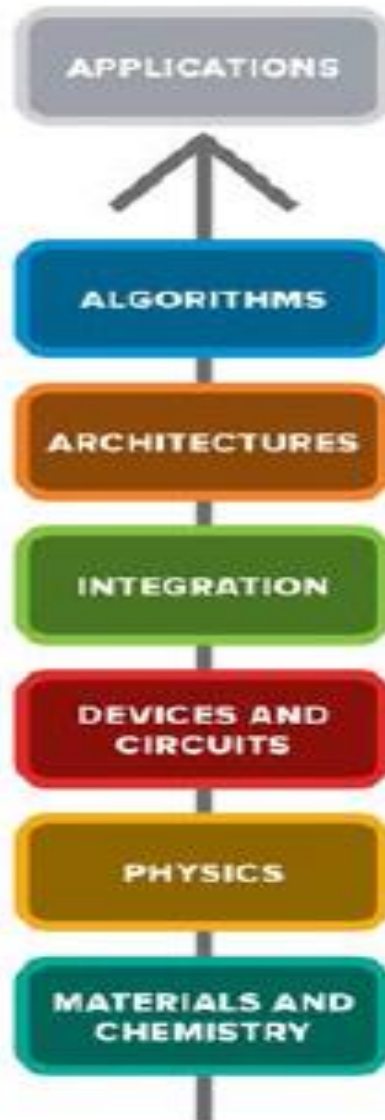
- Power Electronics: Control\*\* of power
- Microelectronics: Control of data
- Other Electronics: Control of photons (e.g., solar cells, LEDs, lasers)

*\* Electronics here means solid-state electronics (semiconductors) on a chip*

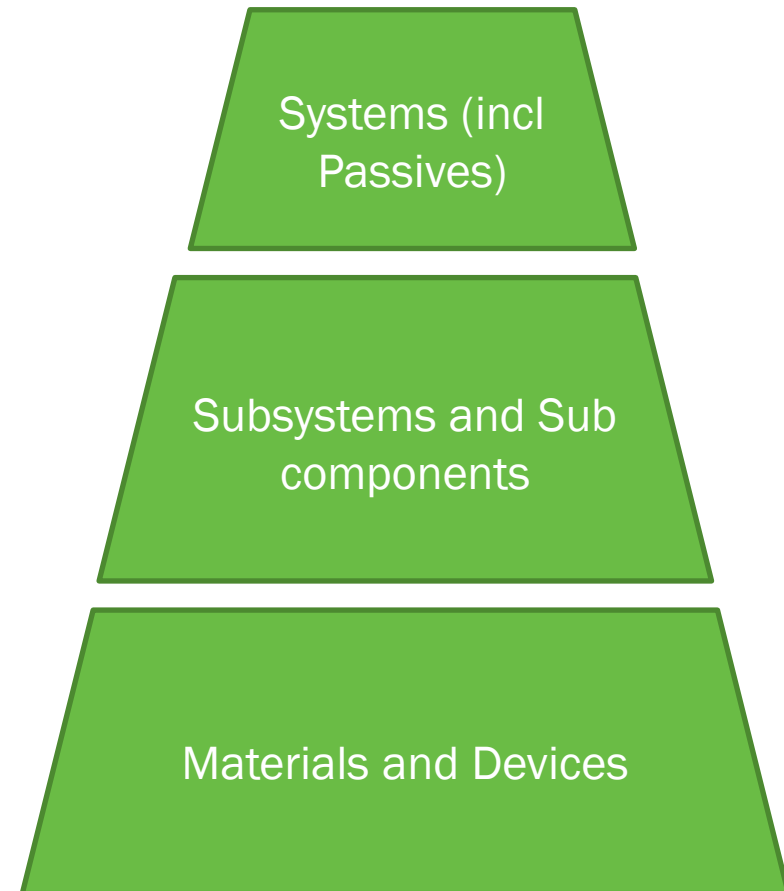
*\*\* Control here includes conditioning, switching, and/or conversion of electric power from alternating current (AC) to direct current (DC) and the reverse*

# Key Figures

## Microelectronics “Stack”



## Power Electronics “Pyramid”



# Why Semiconductors in AMMTO?

## 1. AMMTO benefits Semiconductor Industry

- Key foundational manufacturing technologies built up since 2015

## 2. Semiconductor Industry benefits AMMTO

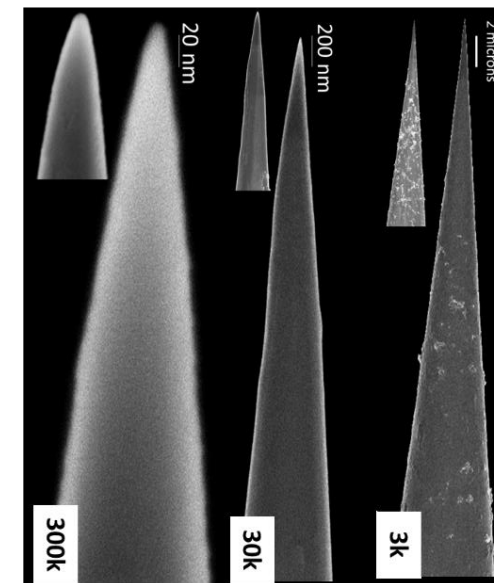
- Semiconductor industry is the epitome of Advanced Manufacturing

## 3. Two AMMTO Semiconductor Roadmaps needed

- Leadership needed on Microelectronics' Energy Efficiency
- In Power Electronics: Leadership needed to
  - To fill gaps (e.g. high voltage for renewables and industry)
  - For a comprehensive materials and manufacturing strategy for electrification

# How AMMTO benefits the Semiconductor Industry

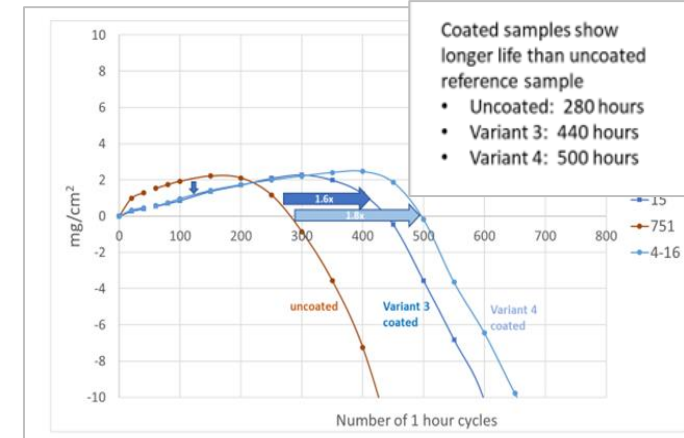
- **Microelectronics: Atomically Precise Manufacturing (~\$30M)**
  - Novel Probes for Tip-Based Atomically Precise Manufacturing: Tiptek, LLC, is a growing small business that has **captured 15% of the world market for nanoprobes** over the last six years. Nanoprobes—tungsten wires sharpened to a near atom-sized point (see STM micrograph right) —are used daily by computer chip manufacturers for a key quality control process called semiconductor nanoprobe failure analysis (SNFA). In April 2023, DOE selected Tiptek as its SBIR/STTR Small Business of the Year!
- **Power Electronics: Wide Bandgap (WBG) Semiconductors (~\$80M)**
  - PowerAmerica: The first ManufacturingUSA Institute launched in 2014, graduated from DOE funding in 2020. Now has over 80 corporate, university and national laboratory members. Its initial focus was on higher TRL WBG Silicon Carbide (SiC) and among its successes was the opening of a fully integrated high volume 150mm SiC Foundry (X-Fab right). US SiC market has increased from \$100M in 2016, to \$400M in 2020!



# How Semiconductor Industry benefits AMMTO

- **Microelectronics: Materials for Harsh Service Conditions**

- Synergistic Coating-Alloy Development for Harsh Environment Applications: Applied Materials (AMAT), one of the U.S. leading semiconductor equipment manufacturers, and an EES2 Pledge signer, has been applying its expertise in developing materials for equipment used in the harsh environment of semiconductor manufacturing to other AMMTO applications through two sequential AMMTO projects.



Preliminary C&F Results from ongoing project funded under DE-EE0009123, showing 1.8x oxidation life improvement for a coated Ni-based alloy A751 coupon (10% water vapor in air @ 950C)

- **Power Electronics: Next Generation Electric Machines**

- Five Recently Completed WBG-based PE inverter drive projects: Calnetix, Clemson, Eaton, GE, and OSU. Compared to “regular” Si-based inverter drives:
  - operate at high voltage which means higher efficiency
  - operate higher switching frequencies (reduces size of passive components to make system compact)
  - handle higher temperatures (simplifies thermal design).



# Why Two AMMTO Semiconductor Roadmaps?

## Rough Relative Size of Recent

Federal Investments

DOD

- CHIPS Hubs

DOC

Power  
America

Other  
Federal

VTO

ARPA-e

Solar

OE

DOE

- SC (ULTRA)
- ARPA-e
- VTO
- SETO
- OE
- AMMTO



CHIPS Act (DOC)

DOE ○

- SC
- NNSA
- AMMTO

CHIPS  
(DOD)



AMMTO, though past support of PowerAmerica and other robust R&D and workforce projects could be well positioned as one of the major funders and a leader in materials and manufacturing R&D—especially for renewables through the just launched Power Electronics Decadal Plan.

AMMTO's microelectronics R&D budget is tiny, but its ideas are BIG. Through its Microelectronics Energy Efficiency Scaling Pledge (~50 signers) and EES2 RD&D Roadmap, AMMTO will convene and influence the entire micro-electronics innovation ecosystem.

\*Energy Efficiency Scaling Over 2 Decades: +1000-fold energy-efficiency over 20 years



# Comparison of Micro- vs Power RD&D Roadmapping

## Microelectronics

1. Micro EES2 RD&D Roadmap v. 1.0 is focused on energy efficiency challenge and U.S. leadership and will identify R&D opportunities from 7 working groups.
2. Was launched Q1 FY23
3. To complete Q1 FY24
4. Roadmapping analysis supported by SLAC and LBNL
5. External Innovation ecosystem involvement through EES2 Pledge (and members like SRC)
6. Close intra-DOE coordination with SC\BES, ASCR and NNSA also w/NIST plus DOD and NSF

## Power Electronics

1. Power “Decadal Plan” will be high-level and focus on 3-5 key challenges with emphasis on decarbonization goals and U.S. competitiveness.
2. Will be launched Q3 FY23
3. To complete Q4 FY24
4. Roadmapping analysis supported by SNL, NREL, and LLNL
5. Close internal coordination with EERE (VTO, HFTO, SETO, BTO), OE and GMI
6. External innovation ecosystem involvement through PowerAmerica



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## **Backup/ Reference**

# AMMTO' GPRA Goal

**Advanced manufacturing processes**, materials, technologies and systems **that demonstrate progress towards commercialization across the clean energy economy**, where progress towards commercialization is demonstrated by at least one of the following:

- Commercialized or implemented in the market
- Attracted follow on funding > cumulative AMMTO investment, excluding project cost share
- Validated cost reduction, performance improvement or lifecycle efficiency improvement meeting published targets
- R&D 100 Award