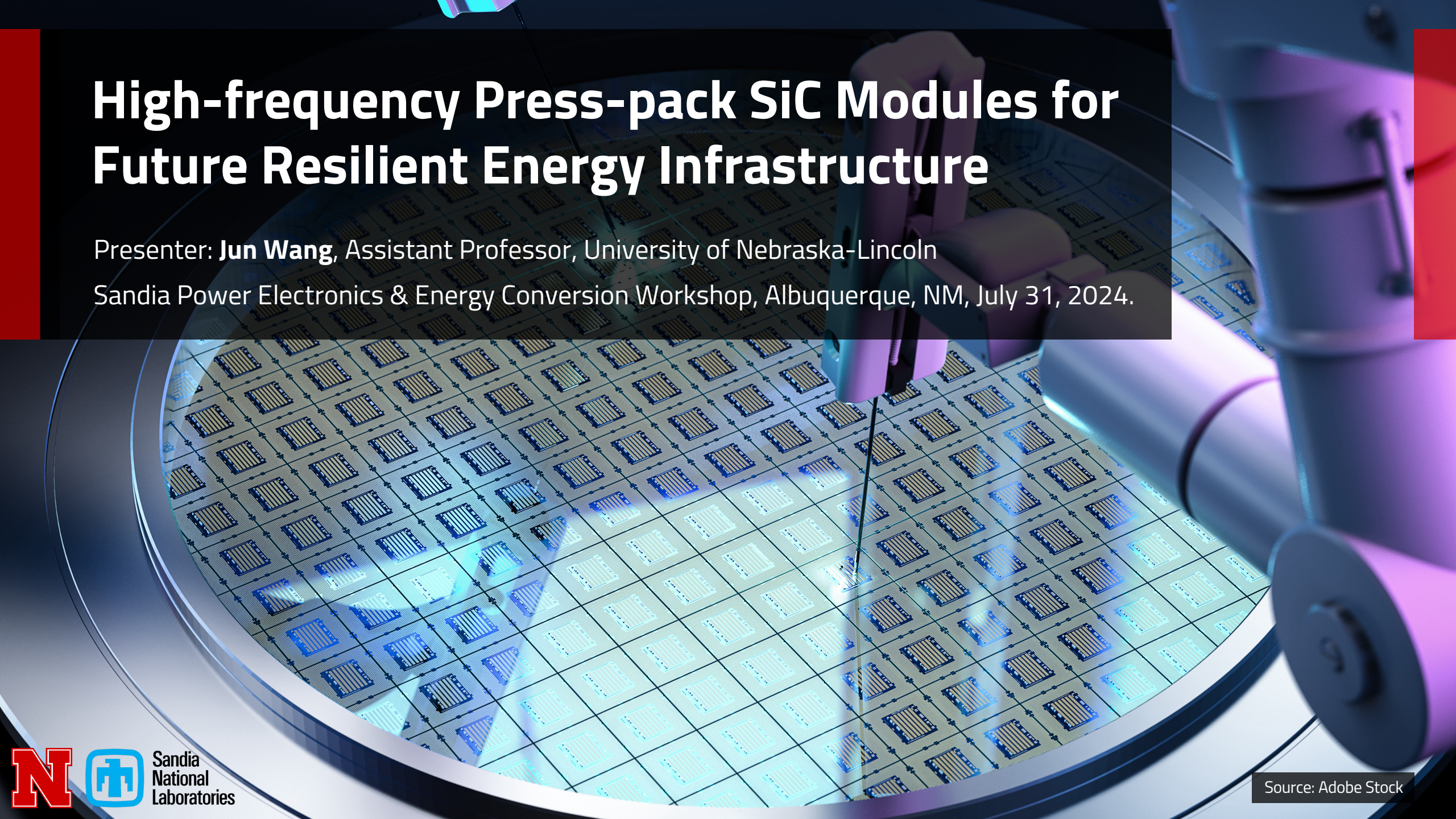
High-frequency Press-pack SiC Modules for Future Resilient Energy Infrastructure

Presenter: **Jun Wang**, Assistant Professor, University of Nebraska-Lincoln

Sandia Power Electronics & Energy Conversion Workshop, Albuquerque, NM, July 31, 2024.



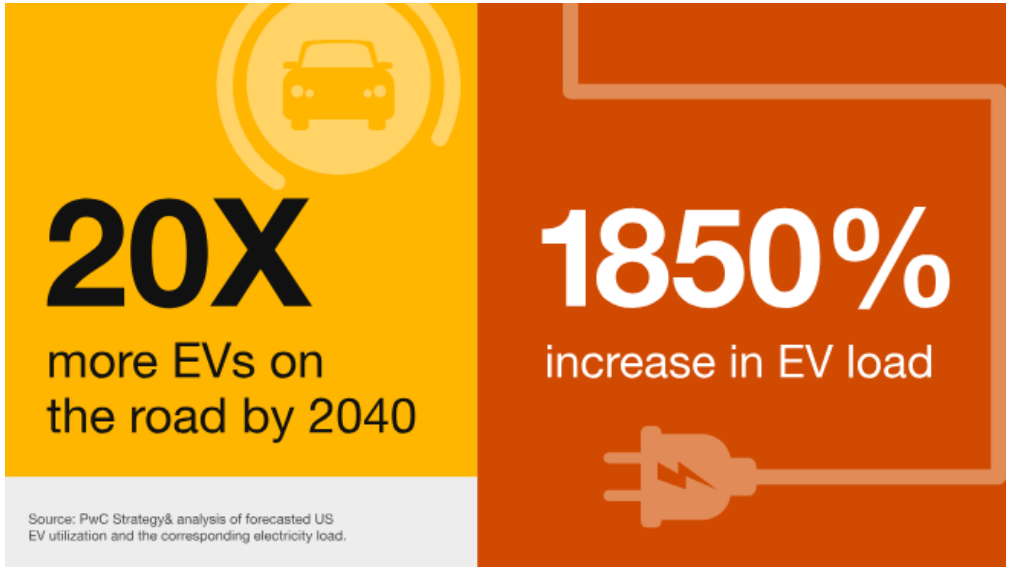
Sandia National Laboratories

Source: Adobe Stock

The U.S. Needs a More Powerful Grid

EV infrastructure: Charging stations

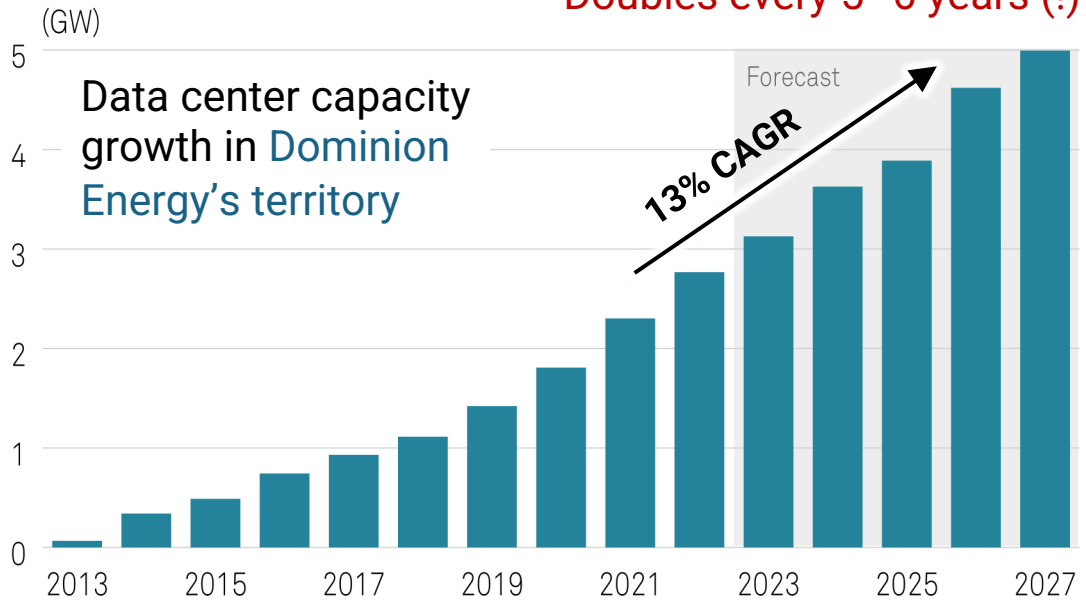
Compared to 2023:



Source: PwC

AI infrastructure: Power-hungry data centers

Doubles every 5–6 years (!)



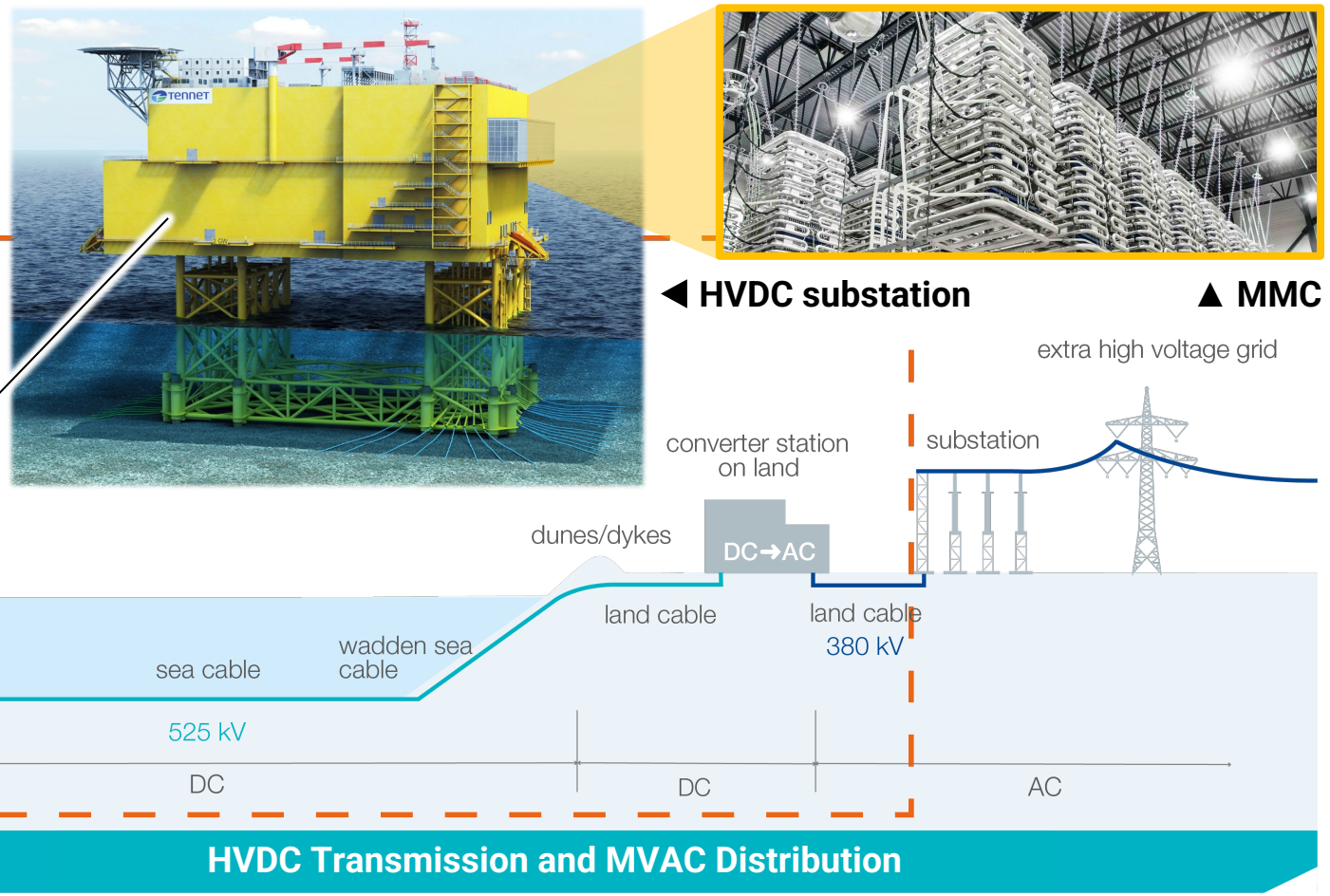
Source: Dominion Energy, cited by S&P

Much more electricity must be delivered to these loads via a more POWERFUL grid (!)

Need for More Advanced Power Electronics

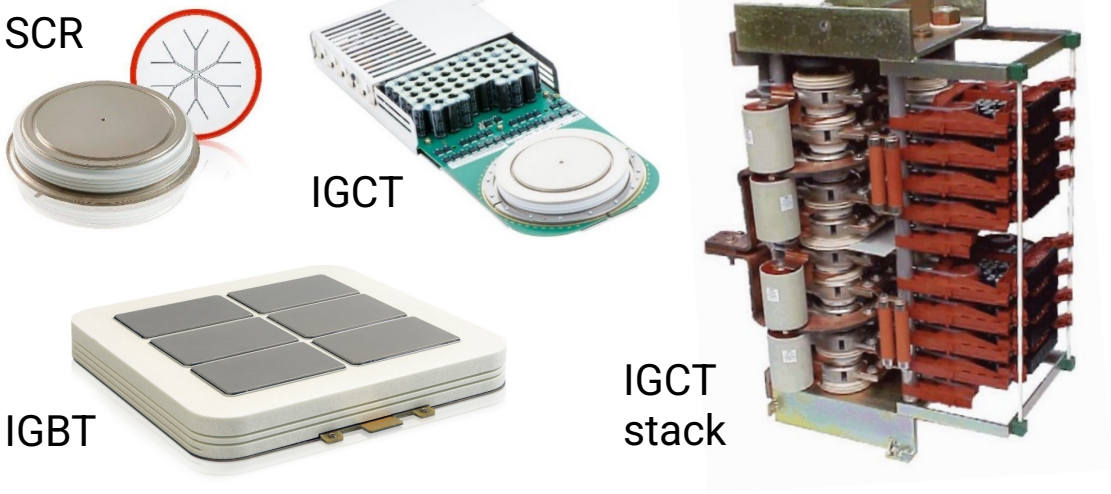
Power electronics is key to providing a more POWERFUL and SUSTAINABLE grid (!)

- **Renewable** electricity generation.
- **Efficient** and **power-dense** electricity transmission and distribution.

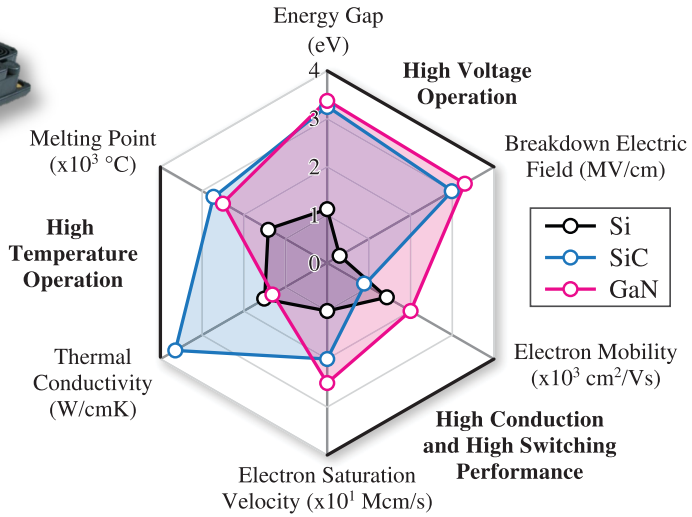


Existing Device Packages are a Bottleneck

SoA-1: Press-pack Si modules and stack for grid application

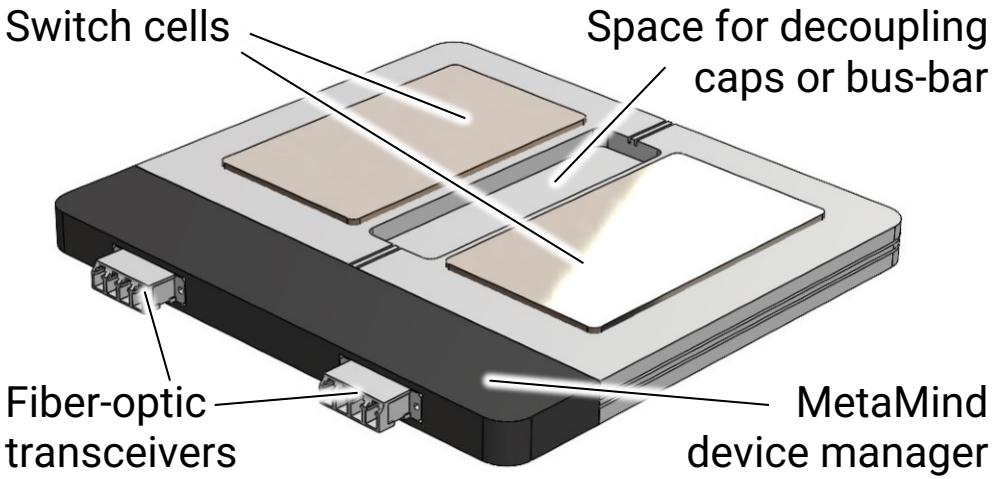


SoA-2: SiC MOSFET/JFET chips are superior, but suitable module is unavailable

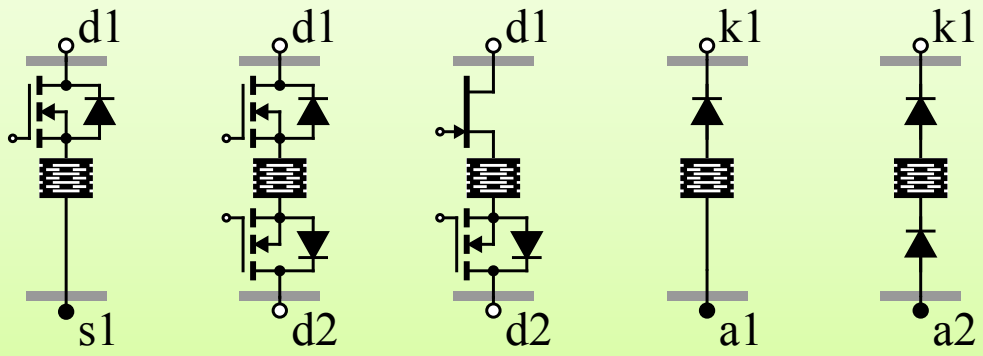


Module property	Conduction loss	Switching loss	Switch. freq./ control BW	Parasitics	Thermal conductivity	Explosion-proof	Integrated gate driver
SoA-1: Si IGBT, IGCT, and SCR	Low	High	Low	High	High	Yes	Partly
SoA-2: SiC FET	High	Low	High	Low	Low	No	No
Proposed SiC FET MetaPak	Low	Low	High	Low	High	Yes	Yes

Proposed MetaPak: New Topology + Package + Intelligence

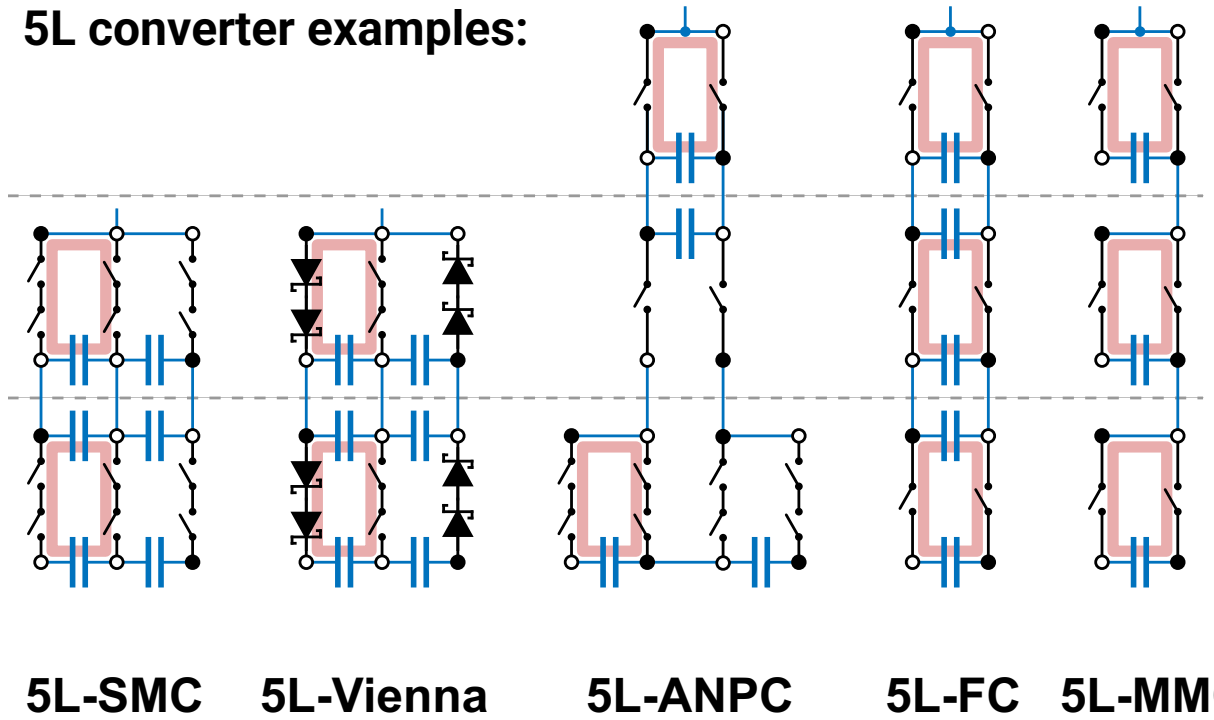


Switch cell topologies



- **Innovation 1: Switch-cell building block (SCBB) architecture with high flexibility and minimized power-loop inductance (< 10 nH). (Patented)**

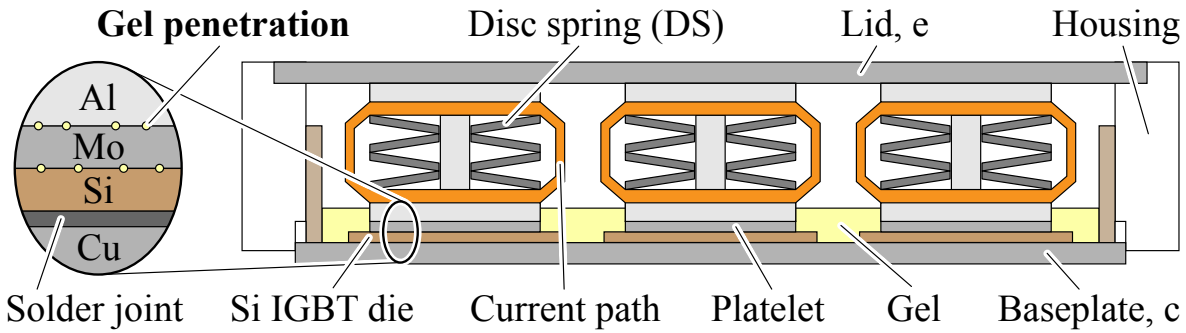
5L converter examples:



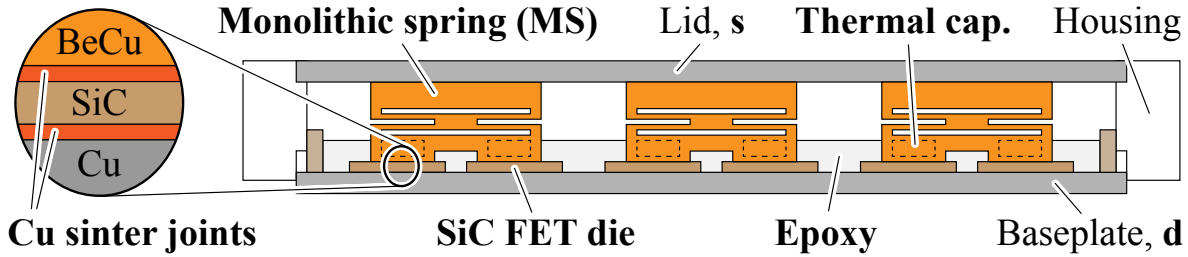
Proposed MetaPak: New Topology + Package + Intelligence

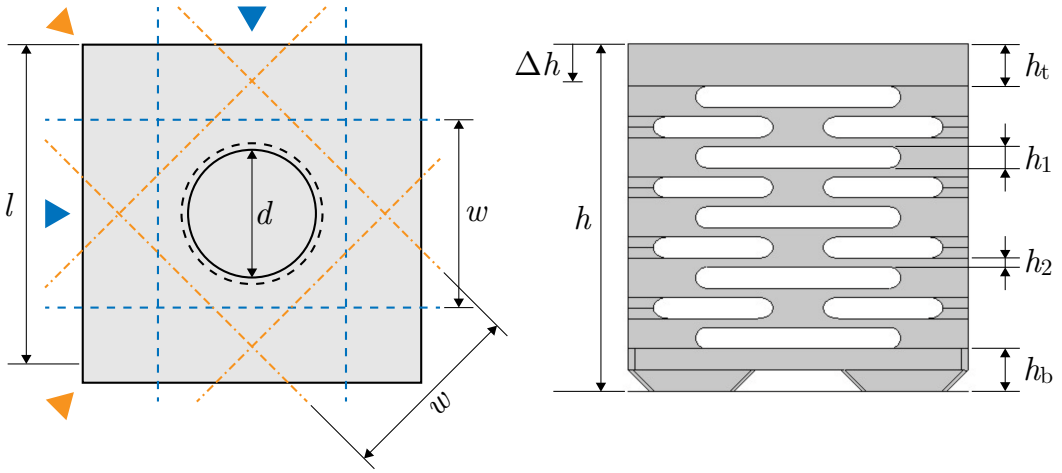
- **Innovation 2: Beryllium copper (BeCu) monolithic spring (MS). (Patented)**

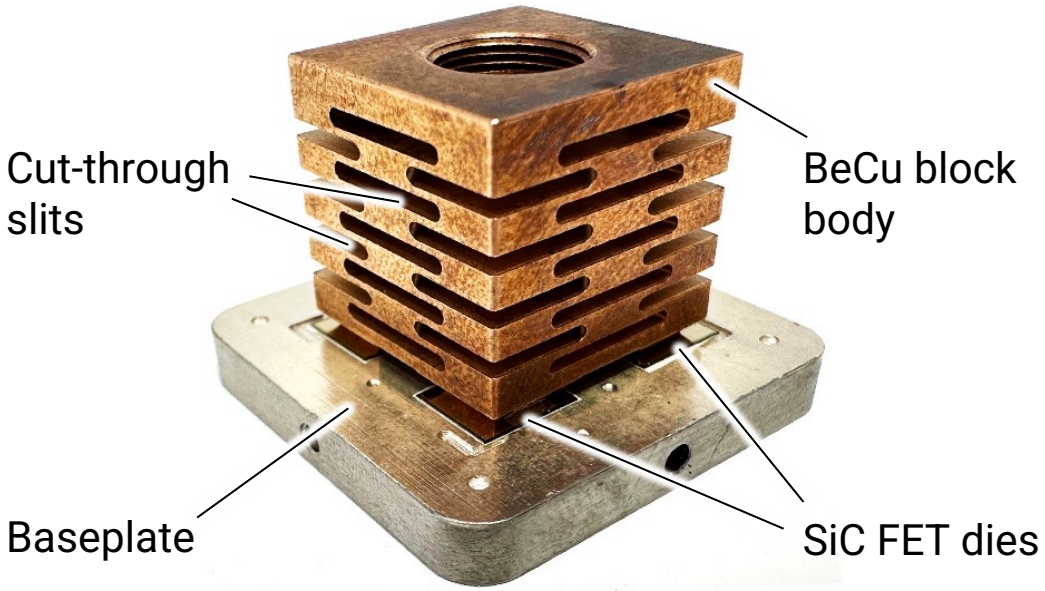
SoA: Hitachi **StakPak™** that fails short (**disc spring**)



Proposed: **MetaPak** that fails short (**monolithic spring**)

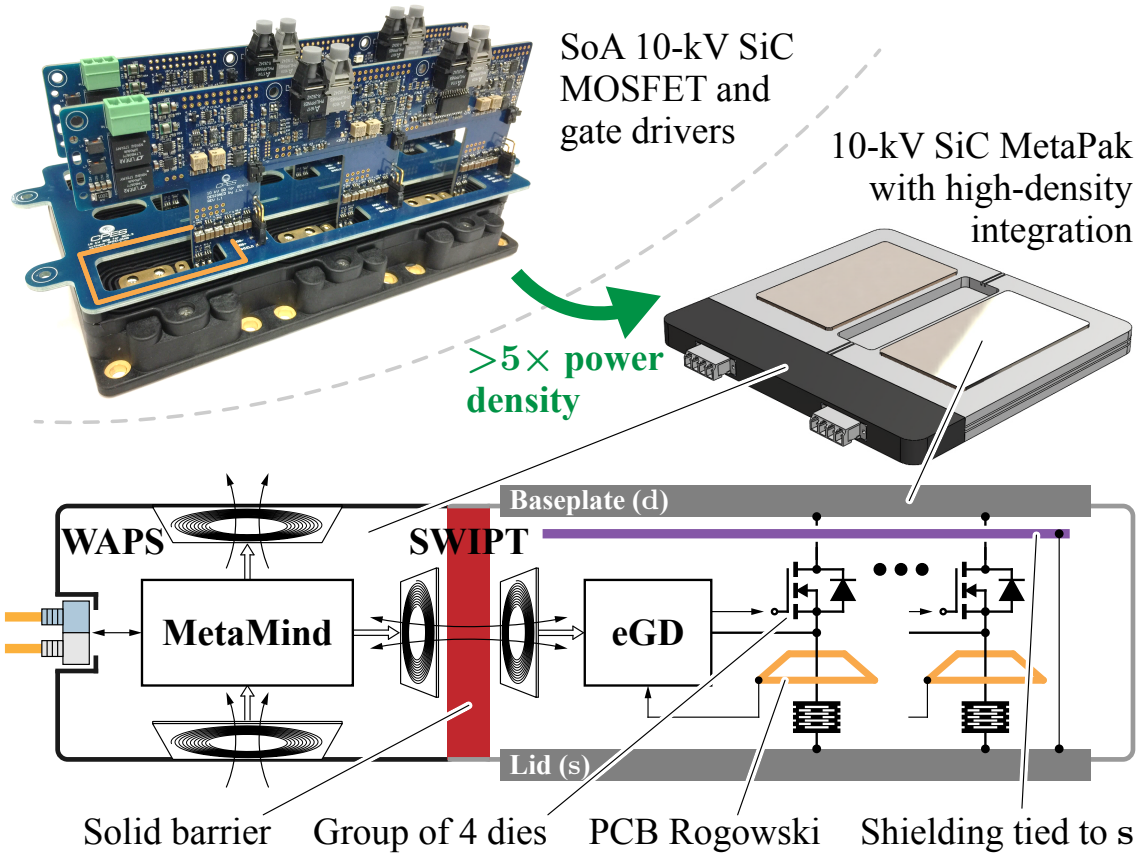


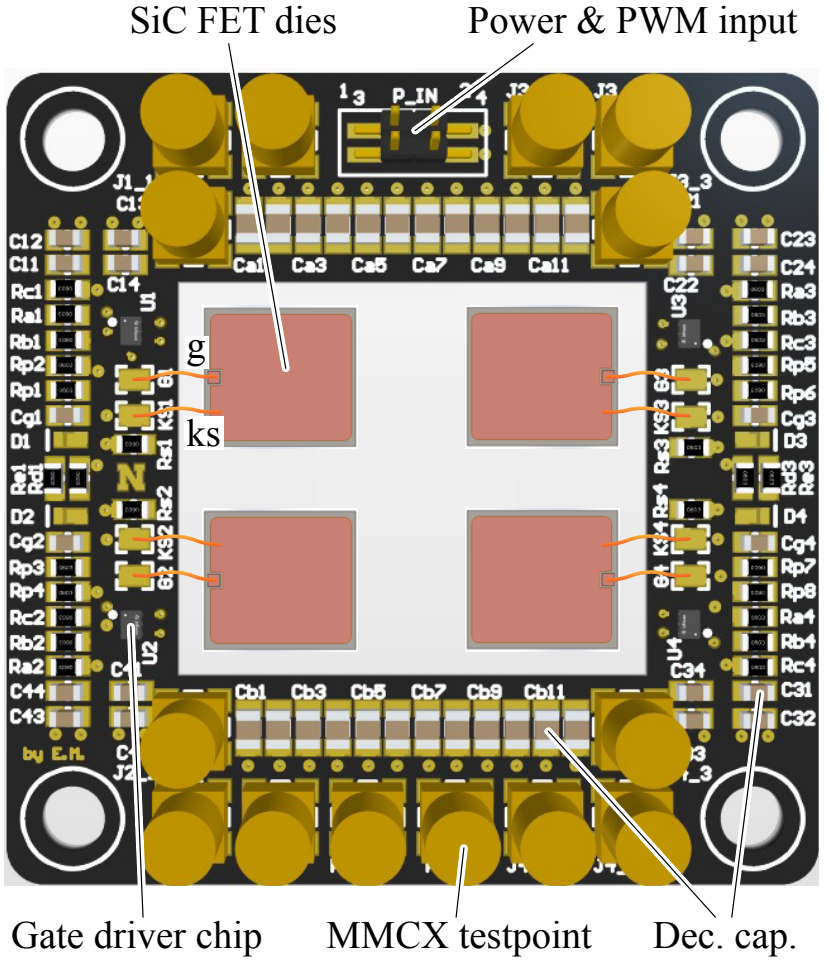




Proposed MetaPak: New Topology + Package + Intelligence

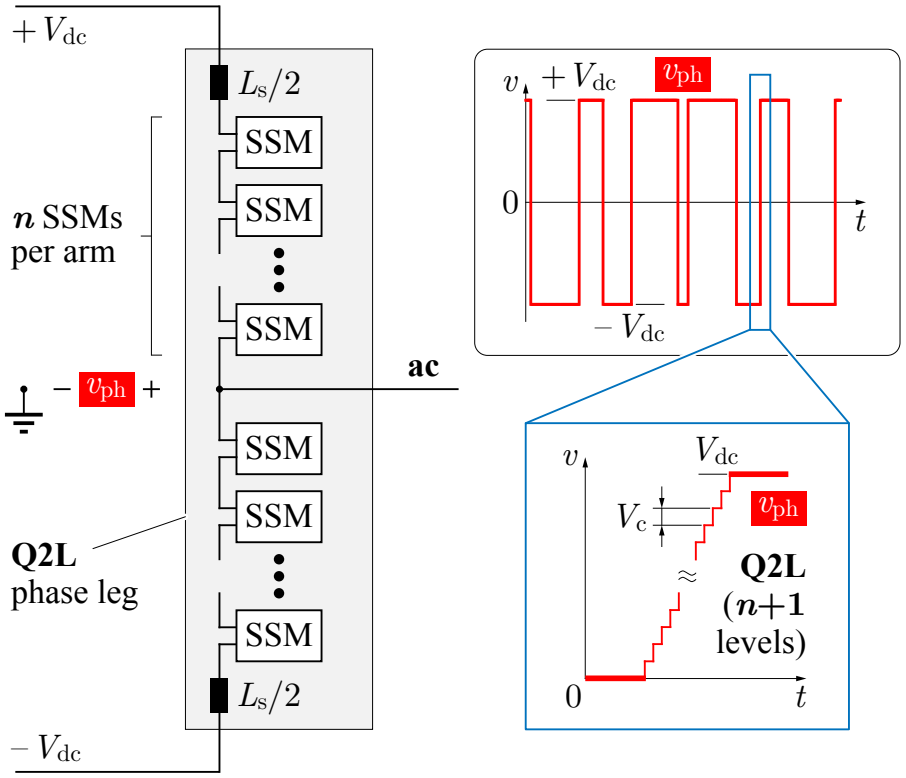
- **Innovation 3: MetaMind device manager and E-field and EMI containment. (Patented)**



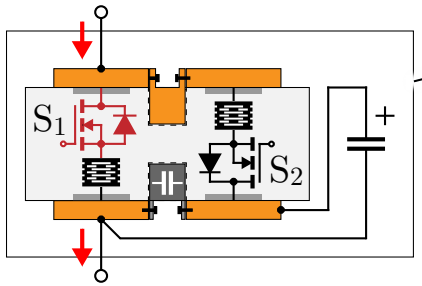


Prospective Impact to Grid Infrastructure

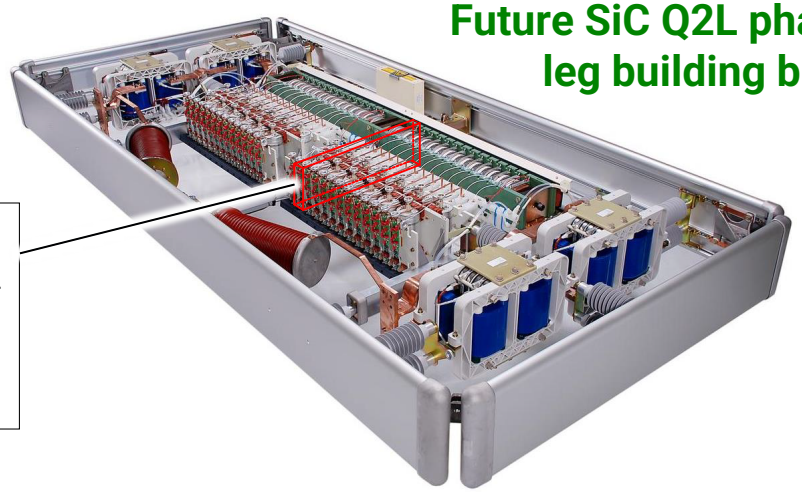
- Enable new **HV converter topologies** and **paradigm-shifting converter designs**.
- Unleash the **untapped potential of HV SiC MOSFETs**.



Stackable submodule (SSM)

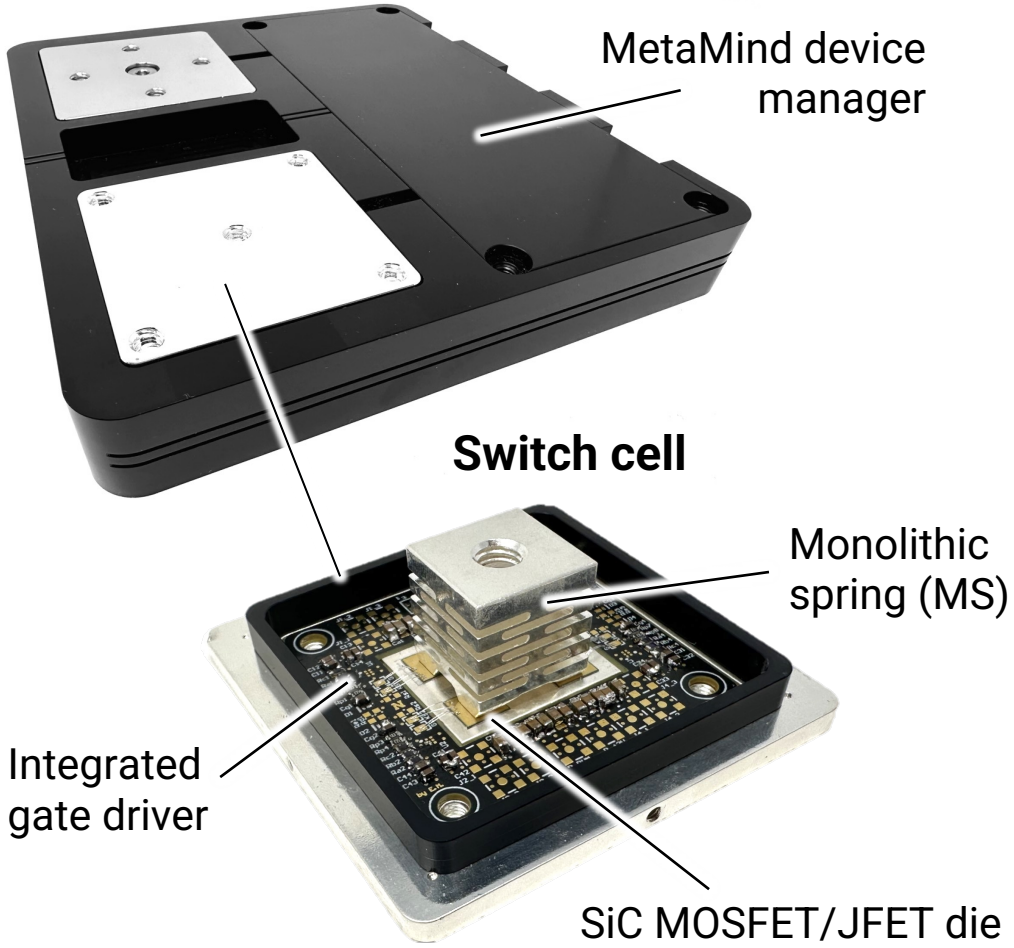


Future SiC Q2L phase-leg building block

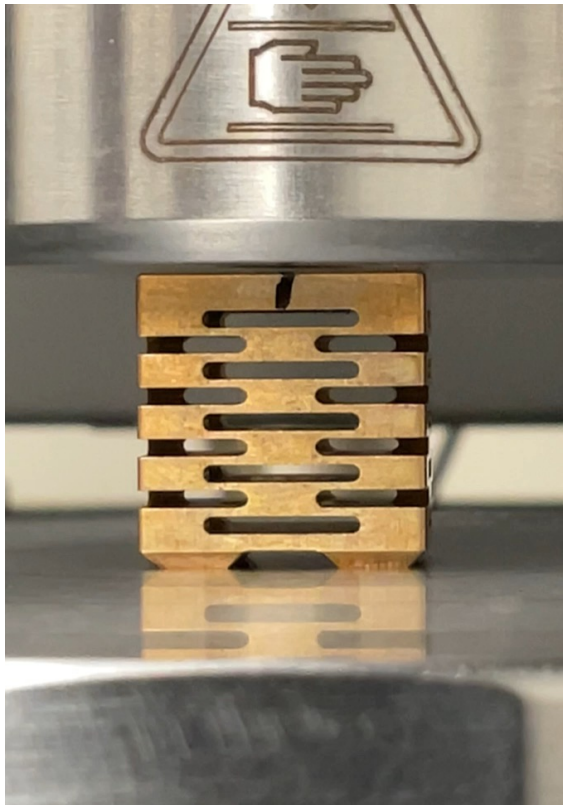


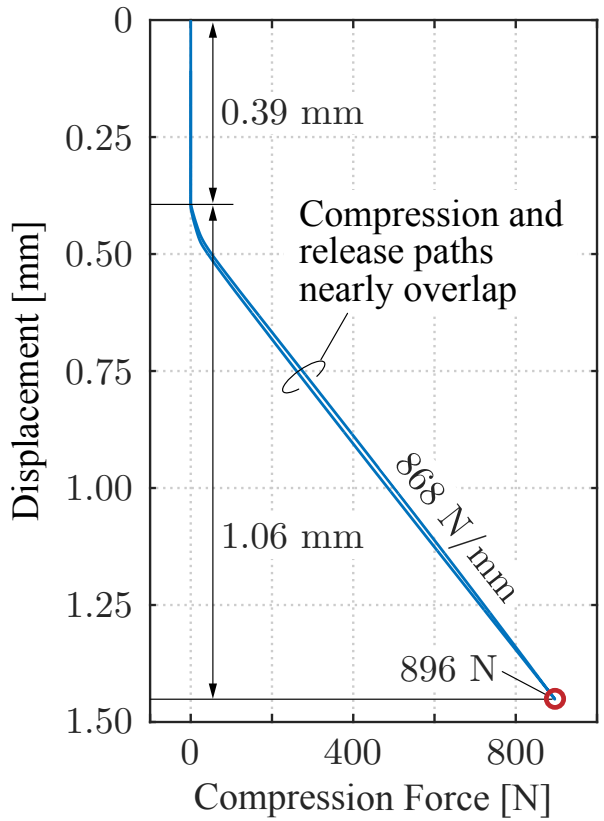
1.2 kV Proof-of-Concept Prototype

MetaPak module



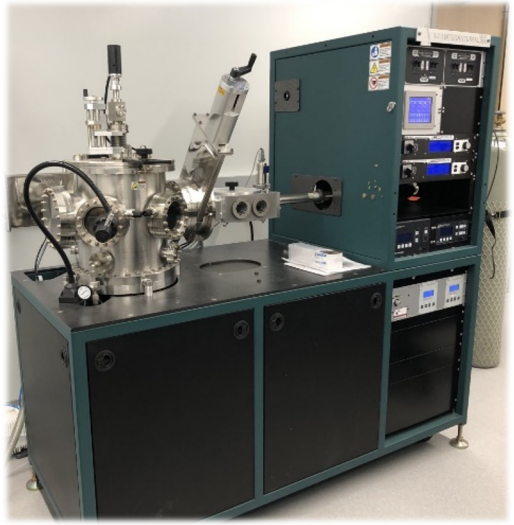
BeCu MS compression test (896 N/1.06 mm)





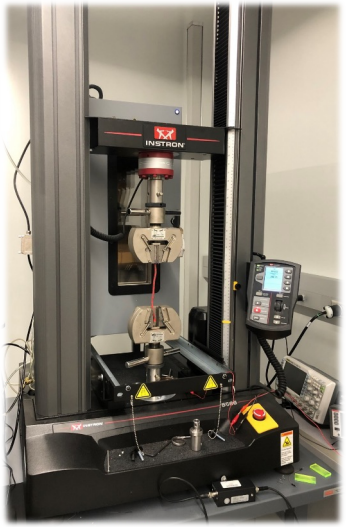
UNL-PESL Facilities (2,500 sq. ft) and Equipment

AJA ATC-2000F



FEI NanoLab 660

Instron 5966



AMX P52

Nordson DAGE 4000 Plus

TPT HB30

Tresky T-5300

• • •

Thank you!

junwang@unl.edu