Multiple Domain Optimized Power Packaging

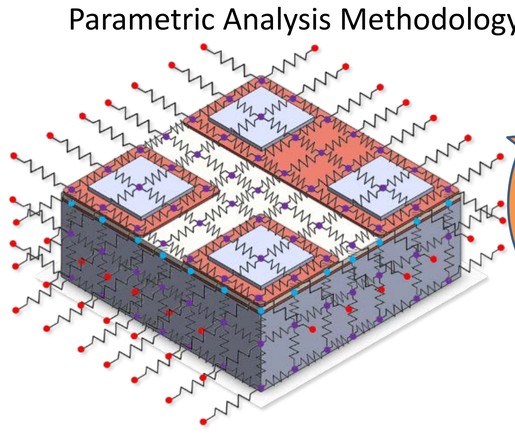
S&T Campaign: Sciences for Maneuver
Energy and Power
Power Energy Conversion

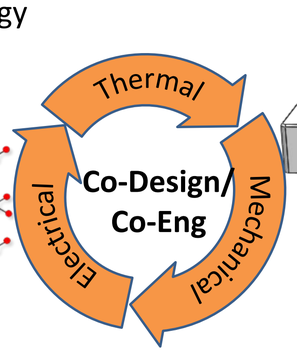
Dr. Lauren Boteler
(301) 394-0970
lauren.m.boteler.civ@mail.mi

Research Objective

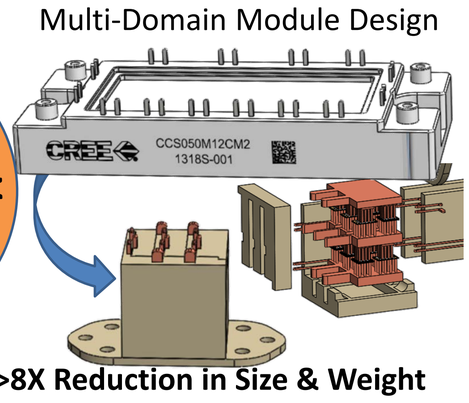
- **The ability to evaluate simultaneously the effects of the thermal, electrical, and mechanical domains on module performance allows significant SWaP improvement in future designs.**
  - **Design and implement a low-fidelity model to quickly analyze temperatures and stresses in a very large parametric space to understand and narrow the design space.**
  - **Establish a new design paradigm which eliminates single function components (ex. wirebonds, heat sinks, solid dielectrics) and replaces them with multi-functional components (MFCs).**

Parametric Analysis Methodology





Multi-Domain Module Design



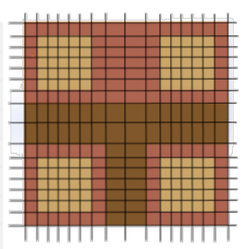
>8X Reduction in Size & Weight

Two-fold research approach for multi-domain optimized power packaging: quick parametric modeling and integrated design.

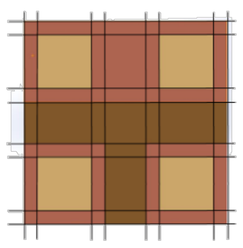
Challenges

- **Finding suitable simple, fast running models for stress, temperature, inductance and transient analysis. Then implementing them via a user friendly GUI.**
- **Determine the lower bounds on model fidelity through comparison to FEA commercial code.**

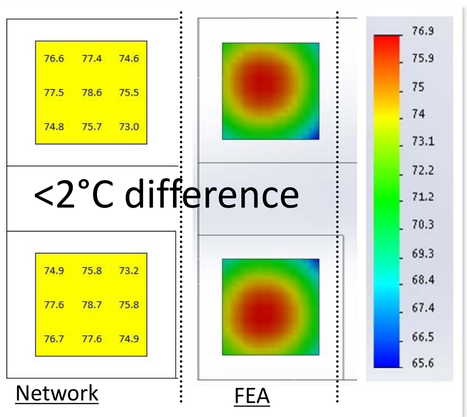
Mesh	Nodes	T_{max} (C)	(MPa)	Time (sec)
FEA Solution				
Coarse	17994	71.4	461.7	21
Medium	53142	74.5	437.2	49
Fine	145771	76.9	432.2	128
Network Solution				
Coarse	343	80.4	489.1	0.25
Medium	1008	78.7	502.7	0.34
Fine	3328	77.6	506.9	0.95



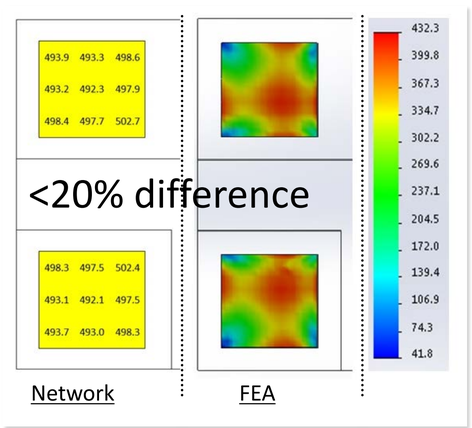
Top: Fine Mesh



Top: Coarse Mesh



Device Temp. (°C) Comparison
(half module shown, symmetric about dotted line)

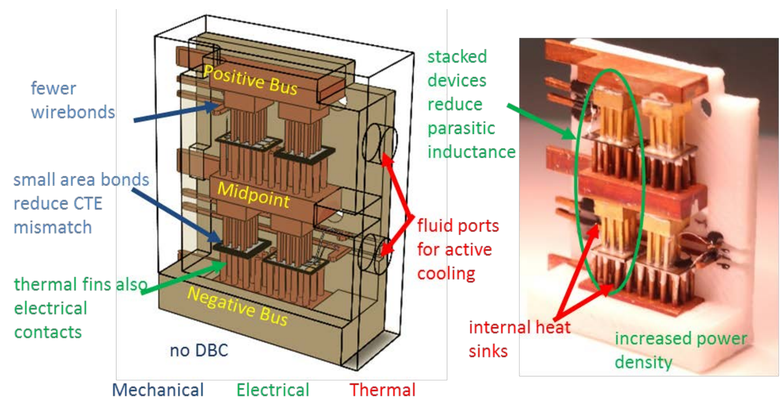


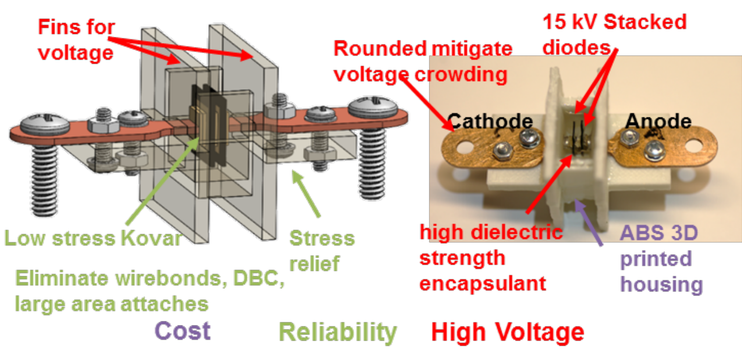
Device Stress (MPa) Comparison
(half module shown, symmetric about dotted line)

Comparison between ARL's ParaPower modeling approach versus FEA commercial code.

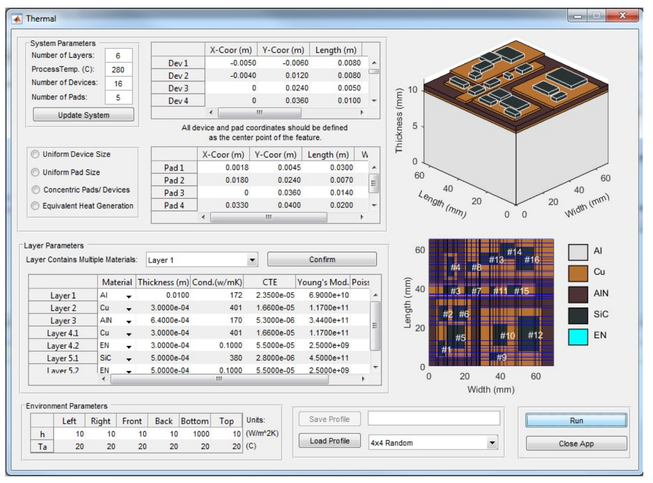
ARL Facilities and Capabilities Available to Support Collaborative Research

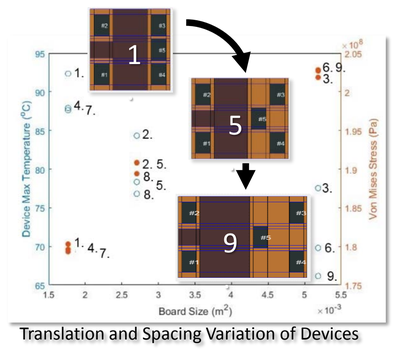
- **Electronics Packaging Lab capable of custom design and fabrication of advanced electronics.**



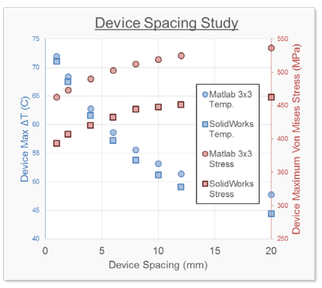


- **ParaPower can analyze large, complicated parametric spaces >100X faster than FEA with reasonable accuracy (<2°C and <20% stress)**





Translation and Spacing Variation of Devices



Complementary Expertise / Facilities / Capabilities Sought in Collaboration

- **Partners sought for ParaPower electrical domain.**
  - **Current models have implemented and validated thermal and mechanical domains.**
- **Partners sought to evaluate and enhance ParaPower for additional electronics designs.**
  - **ParaPower can evaluate most layered structures.**
- **The Army is interested in future electronics packaging designs which include multi-functionality and holistic design methodology.**