Navy Integrated Power Electronics Building Block (NiPEBB): Design and Prototyping

The Navy Integrated Power Electronics Building Block (NiPEBB) is a least replaceable unit (LRU) that will perform power conversion onboard electric ships. A key aspect of the NiPEBB vision is to integrate internal components of the converter into a lightweight (<35 lbs), high power density (~12 kW/l) converter. By leveraging the integration benefits provided by organic substrates, the iPEBB hopes to achieve a 1 kV, 250 kW high-density design. **Error! Reference source not found.** shows the iPEBB concept being explored, with the primary side of the converter shown.

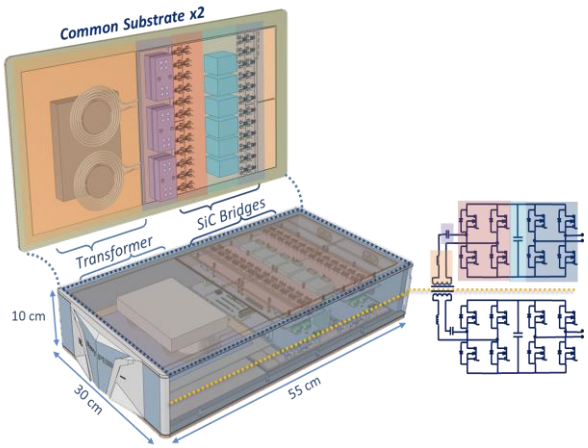

Fig. 1. NiPEBB concept layout based on a common substrate

A SiC MOSFET H-bridge prototype is highlighted in **Error! Reference source not found.**. The converter's primary and secondary sides are based on an organic substrate (ODBC). This substrate spans the entire footprint of the iPEBB and will serve as the electrical, thermal, and mechanical "common substrate" foundation. This common substrate will have components comprising the SiC bridges integrated onto itfor better electrical and thermal performance. The primary and secondary sides of the iPEBB have identical common substrate designs, simplifying manufacturing and reducing cost. The substrates will also have the baseplate directly laminated onto the iPEBB and interface with the rack-level cooling system.

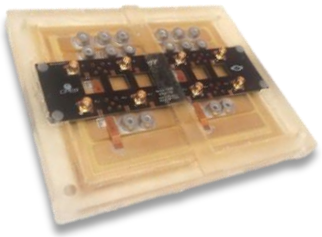

Fig. 2. NiPEBB full-bridge power module

In traditional converter designs where multiple discrete power modules are used, there are multiple interface layers (grease, solder, etc.) This includes the interface between the die and the AlN DBC substrate and between the AlN DBC and the power module baseplate. Furthermore, there is an additional interface where the power module is placed on a converter baseplate to provide mechanical support and cooling. Although this type of design is feasible, it requires redundancies in the design and additional steps and materials, which adds to the cost and complexity of the converter. On the other hand, since the iPEBB uses organic material to form the common substrate, the entire converter can be based on a single manufactured platform that serves as the converter's electrical, thermal, and mechanical foundation. The design and prototyping of the NiPEBB will help advance SiC-based power converters onboard future electric ships.

This work was supported by the Office of Naval Research (ONR) with the grant number N00014-16-1-2956 and N00014-21-12124. Approval number DCN# 0543-0385-23 and 0543-1060-23, Distribution A.