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M4Or1A-02 [Invited]: Dynamic and Static Characteristics of Press Pack IGBT at RT and 77 K

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Superconducting power systems, a promising technology for electric aircraft and all-electric ships, are expected to have many power conversion stages among generators, transmission cables, storage devices, and loads. However, the current technology does not allow power conversion stages to be operated at cryogenic conditions. The lack of such technology deteriorates the overall system efficiency by heat leaking from ambient as electric current exits and enters cryogenic and ambient sections of the system. Therefore, minimizing the number of cryogenic-to-ambient interfaces is important for maximizing system efficiency.
As power semiconductor devices are the main components of power converters, being able to operate these devices at cryogenic conditions is crucial. To enable such capabilities, we characterized the dynamic and static performance of insulated-gate bipolar transistors (IGBT) at room temperature and 77 K. Forward voltage drop and turn-on/off characteristics were investigated at current up to 180 A and voltage as high as 1.0 kV. The cryogenic experiment was designed and built such that moisture condensation is prevented between cryogenic experiments. Such design enabled the multiple iteration of the cryogenic experiment without damaging the power semiconductor device.
The main purpose of this study is to identify megawatt-scale power semiconductors that perform well electrically, thermally, and mechanically at cryogenic conditions. The experimental results provide clearer understanding on the cryogenic use of press pack IGBT's. Furthermore, the results contribute to the materialization of megawatt-scale cryogenic converters for electric aircraft and electric ships.

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