Title of Project: Science of Hetero-Interface of Advanced Power Devices in Extreme Environments

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Research Area: Engineering
Keyword: Electrical connection/Wiring, Power devise, Electromigration

Purpose and Background of the Research
New power semiconductors such as SiC and GaN enable their operation at extremely high temperature beyond 300 °C. In such an extreme environment, thermal, mechanical, optical, and electronic properties should be precisely designed and controlled by understanding the behavior of each material and each hetero-interface (Fig.1). In the present work, a design concept of the advanced power semiconductor structure will be demonstrated, which will be derived from the basic idea obtained by understanding and development of heat-resistant/heat-dissipation structure, anti-corrosion/anti-oxidation treatment, electro-migration (EM) and whisker mechanism/mitigation.

Research Methods
Pure Zn soldering and Ag sinter joining will be adopted to form the devise structure. Through properties evaluation and simulation, the four primary subjects will be promoted as following:
1. Stress relaxation and heat-dissipation: The interconnection structure is evaluated with microstructural and CAE analyses.
2. Anti-corrosion/oxidation design: Interconnection materials/structure will be designed for 300 °C operation in air.
3. EM phenomenen: EM mechanism will be analyzed on interconnection/wiring under large current at elevated temperatures.

Expected Research Achievements and Scientific Significance
The advanced power semiconductor devices of high reliability will be provided through controlling a hetero-interface structure based on the established design concept. They will be applicable for the devices of high-performance renewable energy conversion, low energy consumption devices, energy efficient hybrid/electric vehicles/bullet train, the exploring devices for the earth and the universe.

Publications Relevant to the Project

Term of Project: FY2012-2016

Budget Allocation: 157,800 Thousand Yen

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Fig.1 Influencing factors of hetero-interfaces in new generation of power semiconductors.

Fig.2 Expected advanced devices.