Application of High-Thermoelectric-Power Materials to Self-Cooling Device

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The problem of heating/cooling is currently of paramount importance for the progress of semiconductor devices and circuits since heat dissipation imposes severe limits on the increase in integration density. Joule heat has been increasing from highly integrated silicon devices and power devices such as MOSFET and IGBT. The heat generation per unit area is the same order of the electric heater in the present devices. Thus cooling is very important to keep the performance of these semiconductor devices. The main ways to remove the heat from devices are heat spread by copper plates and heat release to air from a radiation fin. Two decades ago, Peltier modules were used to cool down CPU. But conventional Peltier modules consisting of the usual materials such as Bismuth-Telluride alloys are unsuitable to cool devices generating large heat and are scarcely used to cool down CPU nowadays. Recently, a new scheme to cool down power devices have been proposed and named it self-cooling devices which uses both Peltier effect and thermal conduction **[1,2]**. When the Peltier heat flows in the same direction of the conduction heat, the Peltier heat can increase the cooling efficiency to remove the Joule heat from the device. The self-cooling device material was used a commercial p-type single-crystalline silicon (111) wafer. The thermal conductivity, the thermoelectric power and the electric conductivity at room temperature are 148 W/mK, 545 μ V/K and 100 S/cm, respectively. The self-cooling device has been fabricated by sandwiching silicon wafer between a commercial power MOSFET (IRF1324PbF) and a copper plate. The results from these experiments will be presented at the conference.

[1] Sataro Yamaguchi, ULVAC, **52**, pp.14-17 (2007), (in Japanese).

[2] Hiroshi Nakatsugawa *et al*., Journal of Electronic Materials, **38**, pp.1387-1391 (2009).