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Nanoscale Thermopower Profiling Technique Using a Diamond Themocouple ProbeÂ

Abstract: A scanning seebeck microscopy method is developed to map out the thermopower of a semiconductor with nanometer resolution. This technique profiles the thermopower by simultaneously conducting local heating, temperature sensing and thermoelectric voltage measurement at the tip of a diamond thermocouple probe. The core advantage of this technique is that it enables to get the quantitative thermopower by monitoring the tip-sample contact temperature from the thermocouple junction located at the end of the diamond tip. The diamond thermocouple probe, the key component of the proposed scheme, is fabricated by integrating nano-thermocouple at the diamond tip. The probe should withstand the contact stress higher than 10 GPa, which is necessary for establishing stable electric contact to the silicon surface. The tip and cantilever of the probe are made of boron-doped diamond by means of the silicon lost mold technique, which guarantees a sharper tip apex than that of a diamond coated probe. Then, the gold-chromium thermocouple junction is integrated at the tip apex for simultaneous heating and sensing. The size of the thermocouple is about 500 nm and the radius of the tip apex is less than 50 nm. The measurement technique is demonstrated by measuring the thermopower distribution across a silicon p-n junction. By heating the tip with an AC current and measuring the temperature and thermoelectric voltage between the tip and the sample simultaneously, the thermopower distribution is measured quantitatively. The profiled thermopower follows faithfully the sharp variation over the depletion region of 50 nm width in comparison with the theoretical value obtained from Poissonâ€™s equation. Evaluating from the abrupt change of the phase signal across the junction, the spatial resolution of the method is estimated to be about 5 nm.

Biography: Professor Joon Sik Lee is a professor of School of Mechanical & Aerospace Engineering, Seoul National University, Korea. He received his BS and MS degrees from Seoul National University, and Ph.D. degree from University of California, Berkeley. His research interests are in the modeling and measurements of thermal transport at micro/nanoscales. He has served as Director of the Micro Thermal System Research Center and the Institute of Advance Machinery and Design at Seoul national University. He has also served as Chairman of the Green Technology Committee of the National Science and Technology Council of Korea. His international academic activities are as follows: Editor, Nanoscale and Microscale Themophysical Engineering; Editor, Experimental Heat Transfer; Regional Editor, International Journal of Transport Phenomena; Associate Editor, ASME Journal of Heat Transfer, Editorial Board Member, Computational Thermal Sciences; Vice President, Pacific Center for Thermal-Fluids Engineering; Member, Scientific Committee, International Center for Heat & Mass Transfer; Delegate, Assembly for International Heat Transfer Conferences.