Worldwide R&D

Microscale Thermal Engineering

Takayoshi Inoue, Professor,
Department of Mechanical Sciences and Engineering Graduate School of Science and Engineering, Tokyo Institute of Technology

The primary research activities in our laboratory focus on thermal engineering on a microscale. The research staff at the laboratory currently includes Associate Professor Osamu Nakabeppu, Research Associate Yuji Suzuki, and graduate and undergraduate students of the department.

Although we use the simple term "microscale," this is such an extensive field that we have decided to divide it into two domains. The first is a domain on the order of microns in which devices, such as microchannels, micromachines, or MEMS, can be treated as continuums. The second is a molecular-scale domain in which we consider phenomena on the molecular or quantum level. Nanotechnology, a term that is frequently heard these days, would probably be included in the latter domain. Below, I introduce two or three examples of studies conducted in our laboratory.

The first example is a method for measuring temperatures in microspaces. The most basic activity in thermal engineering research is to measure temperature distributions in target areas with high accuracy. However, optical measurements become impossible at a scale less than the diffraction limit of light. Accurate temperature measurements are also difficult when using a probe because the probe itself affects the measurements. At our laboratory, we mounted a temperature sensor and microheater on the probe of an atomic force microscope and set the probe temperature equivalent to the sample temperature. In this way, we were able to accurately measure temperatures at a spatial resolution of about 25 nm (Fig. 1). It is believed that a precise technology for measuring temperatures at a submicron spatial resolution would be beneficial to the semiconductor industry and the field of micromachines.

Studies on the flows in microchannels are important for CPU cooling and μ-TAS technologies. At our laboratory, we studied the fabrication of a laminated-type micro heat exchanger using microchannels, as well as gas-absorption enhancing technology for microchannel flow.

Finally, we also studied a technology for forming ultra-shallow junctions in semiconductors as a molecular-level thermal engineering technology. The line width in the CPU has been decreased to less than 0.1μm. To keep pace with this, it has become necessary to form extremely shallow junctions of less than 30 nm. There is demand to diffuse impurities uniformly up to 30 nm and to form a steep concentration gradient at depths greater than 30 nm, and also to restore a good crystalline structure. Using simulations, we have studied the feasibility of forming such junctions with laser heating.

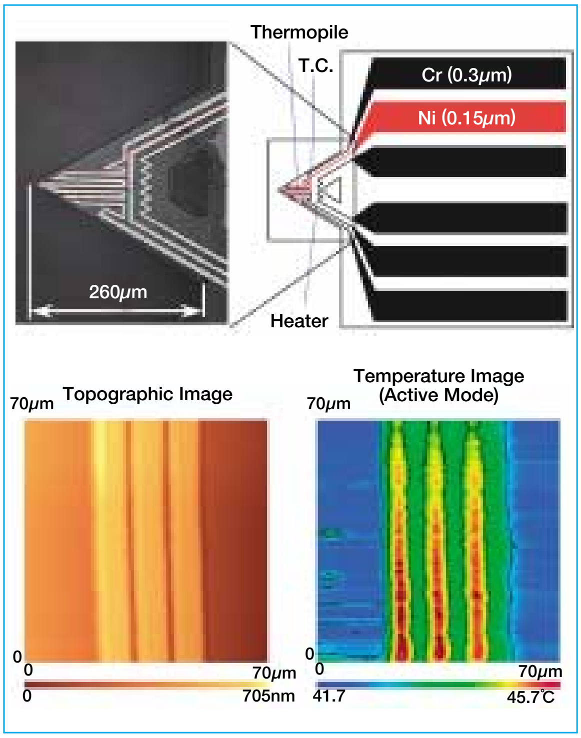

Fig. 1 A probe for measuring temperatures in microspaces and the temperature distribution around fine wires electrically heated

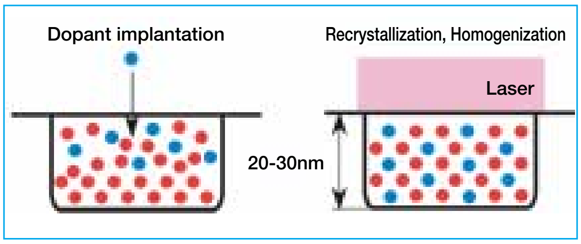

Fig. 2 The formation of an ultra-shallow junction

MICROMACHINE No. 39

MICROMACHINE is published quarterly by Micromachine Center (MMC) to promote the international exchange of information related to micromachines, R&D and other technical topics, and is circulated free of change. Please send your comments about **MICROMACHINE** to the publisher :

Takayuki Hirano, Executive Director, Micromachine Center (MMC)
MBR99 Bldg., 6F., 67 Kanda Sakumagashi, Chiyoda-ku, Tokyo 101-0026, Japan
Tel : +81-3-5835-1870, Fax : +81-3-5835-1873
Internet Home Page http://www.mmc.or.jp/

Change of Address : Please send old address lebel and new address to the publisher.
Editorial and Production Management : Japan Technical Information Service (JATIS)
Date of Issue : May 17, 2002