Micro Components & Systems for Nano/Molecular Eng. (Kim, BJ. Lab.)

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I. Overview Activity (2008-2011) and Future Plan

Our research goals are to build nanosystems and fabricate nanoscale devices, in particular for bio-sensing in singular level, through both bottom-up and top-down approaches.

We focus on interdisciplinary research about local "bottom-up" surface modification using functional self-assembled monolayers and "top-down" approaches for micro/nano patterning technologies. Key technologies concentrate on high-resolution surface patterning with simple, low-cost techniques such as micro-contact printing (μCP), flexible polymer based soft lithography, and micro even nano shadow-masks patterning. In spite of its great versatility, μCP has still many difficulties in the application as a practical patterning technology for a large area. Therefore, we developed the optimized μCP methods in liquid environment and designed hybrid stamp and stamping device to increase the uniformity on the pattern and decrease the deformation of a stamp. Moreover, liquid-μCP technique reduced the collapse of PDMS tips and the diffusion of SAM molecules so that it showed the possibility for practical application to the nano-patterning process in a large area.

Based on these studies on nano/micro components systems for the fabrication of novel nano devices, we investigate to develop various micro sensors for biological applications, such as i) CMOS compatible fabrication of top-gated FET silicon nanowires for detection of proteins, pH level, even metastatic related cancer makers and label-free biosensor components, ii) temperature measurement on resistively heated nanowires for the study on single molecules, and iii) arbitrary-shaped nanochannels fabrication to achieve single DNA stretching, *etc.*

A single biomolecule, DNA now draws much attention, since relevant dimension of nanometer level chips are possible to be made by nano-fabrication techniques. Among many DNA analysis devices, recently nanochannel is highlighted as it provides a proper platform based on DNA stretch phenomenon inside nanochannel. We will continue on the development of complete fabrication of these nanochannels and deep investigation with various DNA or enzyme, bio molecules. Finally, we now aim to realize a tool for the study of temperature dependent phenomena of biomolecules, e.g. DNA and proteins, at a single molecule level.

On the other hands, ***thermal conductivity in nanoscale***, specially affected by contribution of surface phonon-polaritons (SPPs), will be investigated with micro/nano heaters. We aim at the modeling, the fabrication and the characterization of micro/nanostructures (glass tubes) exhibiting anomalous thermal conductivity due to the contribution of SPPs. The dependence to temperature and to nanostructure sizes will be explored in order to possibly reveal several SPPs features such as attenuation length and predominant wavelength.

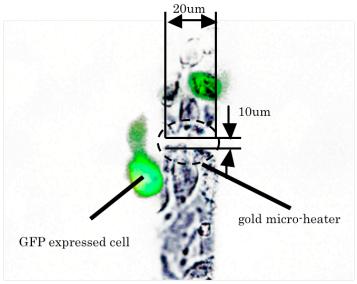

Fig.1 Heat-shock proteins induced by micro heaters.

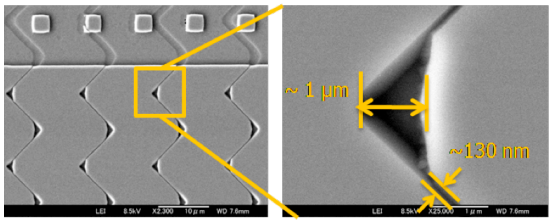

Fig.2 Si Nanochannels with micro chambers.

II. Research Topics related to LIMMS (2008-2011)

(1) Visual observation of liquid micro contact printing (Fattaccioli)
(2) Optical soft-lithography for 3D micro patterning and metal deposition (Fattaccioli)
(3) Nanoscale fluorescent thermometry and nanowire fabrication (Löw and Bergaud)
(4) The first trial for Paper-MEMS- a mechanical switch device with cellulose (Couderc)
(5) Simple fabrication of Si nanowires FET bio sensors (Ginet)
(6) Heat-shock protein synthesis in animal cells induced by micro heaters (Ginet and Volz)
(7) Investigation of Nano heat transfer by Surface Phonon Polariton (Volz)

III. List of Lab. Members (June 2011)

(* former and current LIMMS members)

<Staff Members>
Beomjoon Kim, Associate Professor
Nobuyuki Takama, Technical Staff

<Visiting Scientists>
Sebastian Volz, LIMMS/CNRS, 2008-2010*
<Postdoctoral Fellows>
Jacques Fattaccioli, LIMMS/JSPS, 2006-2009*
Sandrine Couderc, LIMMS/JSPS, 2008-2009* Patrick Ginet, LIMMS/JSPS, 2008-2011

<Students>
Kyungduck Park, PhD Student Jongho Park, PhD Student Ikjoo Byun, PhD Student
Sho Makino, Master Student Shu Cho, Masters Student
Ryohei Uneo, Masters Student Takuro Tokunaga, Masters Student
Oya Koc, Research Student (graduate) Jukyoung Lee, Cooperate Researcher

IV. Research Facilities and Special Machines

(1) Yellow room with double sides lithography aligner, metal evaporation, 3 chemical drafts, wire-bonder, IR-thermal microscopy, SAM treatment dry glove-box, contact angle measurement (Dw304)
(2) AFM/STM lithography, Conventional ATM measurement in liquid environment (De-B01)
(3) WEDG(Wire Electro Discharge Grinding) machine, 3D micro mold machining (De-B01)

V. Selected Publications (2008-2011)

[1] Patrick Ginet, *et al.*, ***Lab Chip***, 11, pp.1513, 2011
[2] Jongho Park, *et al.*, ***Sensors and Actuator A***, 168, pp. 105-111, 2011
[3] Patrick Ginet, *et al.*, ***J. of Micromech. and Microeng.***, 21, pp. 065008 (7 pages), 2011
[4] F. Evenou, *et al.*, ***J. of Biomaterials Science***, DOI:10.1163/092050610X513242, 2010
[5] Y. H. Cho, *et al.*, ***Microfluidics and Nanofluidics***, Vol. 9, pp. 163-170, 2010
[6] Sandrine Couderc, *et al.*, ***Japanese J. of Applied Physics***, Vol. 48, No. 9, 095007, 2009
[7] Céline Bottier, *et al.*, ***Lab Chip***, 9, 1694 - 1700, (DOI: 10.1039/b822519b), 2009
[8] S. Couderc, *et al.*, ***J. of Micromech. and Microeng.***, Vol. 19, No. 5, 055006, May 2009
[9] J.G. Kim, *et al.*, ***J. of Micromech. and Microeng.***, Vol. 19, No. 5, 055017, May 2009
[10] K.D. Park, *et al.*, ***Microelectronic Engineering***, Vol. 86, pp. 1385-1388, 2009
[11] Y.T.Cheng, *et al.*, ***Journal of Physics***, conference series, Vol.152, 012048, 2009
[12] J.W. Kim, *et al.*, ***J. of Micromech. and Microeng.***, Vol.19, 025021 (9 pp), 2009
[13] Peter Löw, et al., ***Small***, 4, No.7, pp. 908-914, 2008

Our web page;
http://www.iis.u-tokyo.ac.jp/~bjoonkim/