NUSNNI FOCUS GROUPS

FOCUS GROUP: **Nano/Micro Fabrication**

FOCUS GROUP CHAIRS: Prof Mustafizur Rahman (Mechanical Eng, FOE)

Prof Frank Watt (Physics, FOS)

Focus Group Information

1. Objectives & Planned Deliverables

Nano/micro fabrication is widely acknowledged to be of fundamental importance to many areas of nanosciences. The group aims to capitalized on current experience and further develop novel conventional and non conventional nano/micro fabrication techniques. These include (i) beam-based processes such as proton beam writing, x-ray lithography and laser nanofabrication, (ii) tool-based nano surface generation processes such as diamond turning and ELID grinding and (iii) tool-based micro machining.

The group aims to establish nano fabrication capability with nanoscale features down to 10 nanometers and below, with form, dimensional accuracy and surface finish down to 1 nm. Capabilities in micro fabrication will also be developed using tool-based techniques such as micro-EDM and micro-cutting to achieve dimensions down to 5 microns. These nano/micro features will be fabricated in both hard and super hard materials such as silicon, glass, ceramics and diamond, and soft materials such as polymers. Techniques will be developed to generate both 2-D and 3-D nano features using conventional/non-conventional material removal processes.

The group's focus will facilitate the nano/micro fabrication for the other sub-groups in areas of nanophotonics and nanofluidics devices, templates for molecular engineering, optical and medical devices, bio-sensors, diamond tools with nanofeatures, and nanostamps for imprinting.

2. Research Plan & Focus

A) Proton Beam Technology

The CIBA group (Centre for Ion Beam Applications) is pioneering proton beam technology. These developments are concentrating on three areas: proton beam writing, proton beam spectroscopy and proton microscopy. ***Proton beam writing***, a new 3D lithography based on direct writing of MeV protons, has now been developed to produce structures down to 20nm. The development of proton beam writing is still in its infancy, and we will continue to develop the technology. New Monte Carlo calculations strongly suggest that proximity effects (unwanted exposure due to scattered secondary electrons) are much smaller than for electron beam writing, making proton beam writing a good candidate for sub 10nm structuring in the future. We are also expanding our applications areas, and working with other members of NUSNNI. Examples of this are: (i) Templates for molecular electronics (Sow Chorng Haur), (ii) Biochips for nanobiomechanics (CT Lim) (iii) Biostructures for the quantum dot incorporation into single cells (Sheu Fwu-Shan) (iv) Templates for nanophotonics (Sow Chorng Haur). In ***proton beam spectroscopy***, we are measuring surfaces of advanced materials at the monolayer levels using Rutherford Backscattering Spectrometry (RBS) – Thomas Osipowicz, and in ***proton microscopy*** we are using protons to image biological cells at the nanolevel.

B) X-ray lithography

The X-ray lithography with synchrotron radiation has been established with the setup of LiMiNT facility in the Singapore Synchrotron Light Source (SSLS). It is designed as a one-stop shop for micro- and

nanofabrication, including the complete process infrastructure for LIGA and nano-XRL projects. X-ray lithography can be used for rapid bulk fabrication of multiple components and structures using masked lithography, and is ideal for multiple component fabrication where the components are 3D and high aspect ratio.

SSLS staff plans to further the x-ray lithography techniques as shown in the collaboration with CAMD (Louisiana State University, USA) in which it has demonstrated the reduction of 380-nm features on a mask to 180-nm features in resist. SSLS is pursuing in-house mask fabrication to further advance the super-resolution process which is expected to enable printing of clear features in the few tens of nm range.

C) Laser Nanofabrication

The laser based fabrication techniques targeted include: (1) short wavelength laser source (157 nm F2 excimer laser and fs laser-induced EUV light generation) for laser interference lithography and surface nanopatterning; (2) ultra-short pulse (pico- and femto-second) laser source induced multi-photon absorption for surface nano-structuring and (3) AFM, NSOM and nanoparticle based light enhancement by near field effect to fabricate nanostructures. And (4) Laser plasmonics effect induced nanolithography (including 3D photonic crystal fabrication for light nanofocussing).

D) Advanced Tool-Based Nano/Micro Machining Techniques

The Micro Fabrication Laboratory and the Advanced Manufacturing Laboratory (AML) in the Faculty of Engineering has considerable expertise in micro turning, micro milling, micro drilling, micro EDM, wire-cut EDM, diamond turning, ELID grinding; These advanced technologies have placed the group in the forefront of machine tool and process development for nano-finishing technology and hybrid nano-micro fabrication.

The research focus for tool-based nano/micro fabrication for the next 3-5 years is on the development of fast/fine tool servo for micro/nano structuring, development of a novel CMP-ELID machine/process for application in the semi-conductor industry, and development of capability to fabricate micro/nano dimension tools for nano structuring. The aim is for developments which can handle features from 100 micron to a few nanometers and surface finish in the order of 1 nm.

3. Websites of Affiliated Focus Group Members & Laboratories

Proton beam technologies (CIBA): http://www.ciba.nus.edu.sg/
CT Lim (Bioengineering): http://www.bioeng.nus.edu.sg/nanolab/nanolab.html
Sow Chorng Haur (Physics)
Sheu Fwu Chan (Biological Sciences)
Thomas Osipowicz (CIBA – Dept of Physics): http://www.ciba.nus.edu.sg/

Singapore Synchrotron Light Source : http://ssls.nus.edu.sg/

Laser Nanofabrication: http://www.ece.nus.edu.sg/laserlab/

Micro Machining : http://serve.me.nus.edu.sg/musta/Micro_MC.htm

Nano Surface Generation : http://serve.me.nus.edu.sg/musta/Nano_Ni.htm ;
http://serve.me.nus.edu.sg/musta/ELID.htm;
http://serve.me.nus.edu.sg/nanomachining/