NFFA – Europe Pilot (NEP) project

WP13 - JA3 - Nano-Engineering and pattern transfer methods
Members of the JA3: CSIC (Barcelona, Spain) C2N-CNRS (Paris, France), Lund University (Lund, Sweden), EPFL (Lausanne, Switzerland)

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On-line Workshop

Nanoengineering: Lithography and Patterning

A brief description of the workshop
The current workshop serves as a platform for interaction and exchange of ideas between members of the Joint Activity ”Nano-Engineering and pattern transfer methods” of NFFA-Europe Pilot (NEP) project and the invited external participants. Its scope includes presentations and discussions of advanced approaches of ultra-high resolution lithography and methods of patterns transfer. Of special interest are nanofabrication techniques that can be used in quantum technologies, but further developments and innovative aspects of generic technologies, such as electron- and ion-beam lithography, scanning probes, self-assembly, etching, deposition, are of interest, too.

Date: December 10, 2021, 13.00 – about 17.15
Venue: on-line, Zoom
Zoom address:
TOPIC: NEP JA workshop. Nanoengineering: Lithography and Patterning
WHEN: Dec 10, 2021 13:00 Stockholm
WHERE: LU Zoom meeting: https://lu-se.zoom.us/j/63703855859?pwd=UzYzeEpUSVlxM3VNSmg4WGlYcnNNdz09

You can also join the meeting by entering the following information in the Join a meeting dialogue or in the Zoom app:
Meeting ID: **637 0385 5859**
Password: **338233**
Presentations: 15 min + 5 min for questions (invited 25 + 5 min)

Program:

13.00 – 13.10:	Welcome and Introduction
13.10 – 13.40:	INVITED. *Development of Deterministic Ion Implantation for Applications in Quantum Technologies*, Daniel Spemann, Paul Räcke et al, Leibniz Institute of Surface Engineering (IOM), Leipzig, Germany
13.40 – 14.00:	*Silicon Nanowires with Quantum Dot as a Platform for experimentation in Quantum Tecnologies*, Jordi Llobet, Francesc Perez-Murano et al, IMB-CNM CSIC, Barcelona, Spain
14.00 – 14.20:	*Focused beams patterning of metal-oxides synthesized by Polymer Assisted Deposition*, Dominique Mailly, Andrea Cattoni, C2N-CNRS, Paris, France
14.20 – 14.30:	Break
14.30 – 14.50:	*Block copolymer lithography for feature reduction and sub-10 nm patterning*, Anette Löfstrand et al, Lund University, Lund, Sweden
14.50 – 15.10:	*Unconventional patterning by nanostencils and thermal scanning probes*, Ana Conde-Rubio, Juergen Brugger, et al, EPFL, Lausanne, Switzerland
15.10 – 15.30:	*Post Treatment Processing for High-Resolution Displacement Talbot Lithography*, Ivan Maximov, Reza Jafari Jam et al, Lund University, Lund, Sweden
15.30 – 15.40:	Break
15.40 – 17.15:	Free discussion. Conclusions.

Abstracts:

Development of Deterministic Ion Implantation for Applications in Quantum Technologies

D. Spemann[a,b], P. Räcke[a,b], J.W. Gerlach[a,b], J. Meijer[b,c]
[a]Leibniz Institute of Surface Engineering (IOM), Leipzig, Germany
[b]Leibniz Joint-Lab „Single Ion Implantation", Leipzig, Germany
[c]Felix Bloch Institute for Solid State Physics, Universität Leipzig, Leipzig, Germany

At the Leibniz Joint Lab "Single Ion Implantation" deterministic ion implantation, i.e. the implantation of counted single ions, a key technology for solid state quantum technology applications, is currently under development. For the ion detection, a pre-detection approach has been chosen that is based on the image charge created in an array of electrodes as the individual ion passes through. As the detection signal is proportional to the ion charge, highly charged ions significantly enhance the detection sensitivity. Hence, a focussed beam of highly charged ions is necessary for our approach. Therefore, a FIB based ion implanter equipped with an electron beam ion source (EBIS) was set up. We present some basics of deterministic ion implantation and our experimental setup, report on the present state of the development and address some challenges ahead.

Silicon Nanowires with Quantum Dot as a Platform for Experimentation in Quantum Technologies

J Llobet, F. Perez-Murano et al, IMB-CNM CSIC, Barcelona, Spain

Silicon Nanowires (SiNWs) are basic building blocks for the development of semiconductor spin qubits based on quantum dots. We are developing a platform to test nanofabrication processes for the fabrication of better devices. To build the platform we are following two mix-and match approaches for the definition of the SiNWs: i) optical and electron beam lithography (EBL); ii) focused ion beam implantation and EBL.

Focused beams patterning of metal-oxides synthesized by Polymer Assisted Deposition

Dominique Mailly, Andrea Cattoni, et al, C2N-CNRS, Paris, France

Polymer assisted deposition (PAD) is a chemical solution route to high quality thin films of simple or complex metal oxides (Nature Materials 3, 529). This technique employs metal ions coordinated to polymers as the film precursor. The use of polymer bound metals has several advantages, including: water-based precursor solutions stable for months, homogeneous distribution of metal precursors in the solution and in the films even in presence of a different chemical reactivity among metals. In this contribution we demonstrate He-FIB and electron beam patterning of environmentally friendly water-developable metal oxide films synthesized by PAD.

Block copolymer lithography for feature reduction and sub-10 nm patterning

Anette Löfstrand,*[a] Reza Jafari Jam,[a] Karolina Mothander,[b] Tommy Nylander,[b] Muhammad Mumtaz,[c] Alexei Vorobiev,[d] Wen-Chang Chen,[e] Redouane Borsali [c] and Ivan Maximov*[a]
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[d] Division for Materials Physics, Department of Physics and Astronomy, Uppsala University, P.O. Box 516, SE-751 20 Uppsala, Sweden
[e] Advanced Research Center for Green Materials Science and Technology, National Taiwan University, Taipei 10617, Taiwan

Self-assembly of block copolymer having high immiscibility of blocks enables patterning of features below 10 nm. Here, we present selective infiltration of alumina into one of the polymer blocks in sequential infiltration synthesis, for pattern transfer of 5 nm features into silicon. Also, the general principles regarding the possibility of reduction of an existing lithographic feature dimension by self-assembling block copolymer along the feature edges will be presented.

Unconventional patterning by nanostencils and thermal scanning probes

Ana Conde-Rubio, Juergen Brugger, et al, EPFL, Lausanne, Switzerland

We present an overview of two nanopatterning techniques that do not rely on high energy charged particles and are thus candidates to pattern fragile material systems.
Stencil lithography enables patterning nm-sized features through the direct deposition of complex materials without the need of a photoresist. Stencil masks can also be adapted for localized etching and ion implantation processes (Microelectron. Eng. 132, 236-254). Thermal scanning probe (tSPL) has emerged as an alternative solution for nanolithography with applications ranging from quantum technologies to biology. Free from electrons, this technique relies on the use of a sharp-heated tip for the direct writing of sub-10 nm features,

precise greyscale patterning and marker-less stitching. tSPL can also be used to directly induce modifications in some materials or for the addition of a functional material (Microsyst. Nanoeng. 6, 21).

Post Treatment Processing for High-Resolution Displacement Talbot Lithography

Ivan Maximov, Reza Jafari Jam, Mariusz Graczyk, et al, Lund University, Lund, Sweden

Although, the Displacement Talbot Lithography (DTL) with ArF-laser is capable of a large-scale patterning of sub-100 nm features for use of e.g. growth of III-V nanowires and other applications (*Nanotechnology* **31**, 1–9, 2020), it is possible to fine-tune sizes by a post lithographic treatment. In our report we present a simple approach how to decrease the diameter of holes in double-layer resists after DTL using an additional layer of a shrinking polymer. Applications of this approach for lift-off and reactive ion etching pattern transfer are discussed.

Ivan Maximov is inviting you to a scheduled LU Zoom meeting.

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