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# Microelectronic Engineering

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## Preface

For an open focused thematic special issue of Microelectronic Engineering Micro/Nano Fabrication 2014, Short title: Nano Fab 2014 also including selected papers from the 40th Micro and Nano Engineering conference MNE 2014  
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In 2015 we celebrate the UNESCO ‘Year of the light’, 150 years of the first ascent to the Matterhorn (1865) and 20 years after of the first publications on “nanoimprint lithography” (NIL). While photolithography has become the workhorse of high volume manufacturing (HVM) of semiconductor chips, it is uncertain whether semiconductor chip manufacturing will follow the normal path of downscaling by using EUV-lithography. Everything seems to be ready but other techniques might win due to technological or cost issues. NIL has reached maturity and starts to replace photolithography in sapphire substrate patterning for light emitting diodes (LED) and will possibly make its way into manufacturing of semiconductor chips in 2016. During the last years, Microelectronic Engineering (MEE) has covered the ascent from several lithographic techniques from “exploratory research” and “next generation lithography” to HVM. Tools and materials seem to be ready and processes are developed which meet the requirements of a growing user community. The next years will show whether techniques will become widely used and successful, or will dwell in some laboratories until they finally will vanish. It is still an endeavor to follow this path of different micro- and nanofabrication techniques which are the heart of many micro- and nanotechnological applications.

This special issue on “Micro/Nano Fabrication 2014” contains a selection of papers which were mainly presented on the “40<sup>th</sup> Micro and Nano Engineering, MNE 2014 conference” held from Sept. 22–26 in Lausanne, Switzerland.

The MNE conference series focuses on micro- & nanofabrication and manufacturing using lithography and other nanopatterning related approaches, as well as the application of micro- and nanostructures and devices in electronics, photonics, electro-mechanics, for the environment and life sciences. The large number of submissions was selected papers from five relevant topical themes of the MNE 2014 conference, which were condensed to the four special issues. At MNE 2014, 670 abstracts were submitted from 45 countries, numbers surpassing all previous MNE conferences. The conference program comprised 585 contributions. The special issue on Micro/Nano Fabrication 2014 is one of four issues covering the five conference topics, which were condensed to four special issues of Microelectronic Engineering (volumes 141, 143, 144, and 145).

For the special issue on “Micro/Nano Fabrication 2014”, 87 papers were submitted, which each underwent critical review by at least two experts in the field with a rejection rate of 39%. In total,

the 87 submissions account to 50% from the original 167 accepted abstracts from the thematic topic “Micro and Nano Fabrication Methods” at the MNE 2014 conference.

The special issue on “Micro/Nano Fabrication 2014” covers the core of “alternative” and innovative patterning techniques such as nanoimprint and soft lithography techniques which clearly developed to the small-scale patterning of today’s devices. Gaining fundamental insights and exploring further these alternative patterning techniques opens new avenues towards new material functionalities and their integration as functional building blocks to novel device prototypes. In particular, stamp fabrication, processes and imprinting methods, applications, dedicated resists, systems, and alignment were in focus at the conference. As a complement, novel machinery, stamps and materials were presented by tool and material producers at the technical exhibition revealing the actual step from research to products. At the same time, new topics and materials are presented which deserve the term “exploratory”, i.e. scanning probe techniques, 3D lithography and ink-jet printing, along with novel fabrication methods such as directed self-assembly, block copolymers and combination of top-down and bottom-up processes. Here, significant steps have been made towards industrialization. Excitingly, one may exemplify that 3D lithography can now be done at different length scales, from feature sizes of a few nm up to a few mm. This is presented in more detail in an opinion paper by R. Kirchner et al. about “The ascent of high resolution and high volume 3D replication” in this issue. Because of MEE’s strong focus on processing, pattern transfer and plasma etching is of high interest for many process engineers and researchers. This includes nanoscale etching, lithography/etching interactions, etching of new materials, etch damage, deep etching, lateral etching, but also lift-off, plating, sputtering/milling, beam etching/deposition, and modelling. This special issue was therefore particularly welcoming process-related papers which give researchers and engineers more insight into how a process is performed rather than what can be actually manufactured with this process.

At the time when nanoimprint lithography is used in manufacturing for LEDs and is approaching production in semiconductor industry, new process variants are still developed and needed. One of those is “Sub-100 μm nanoimprint lithography at wafer scale”, by M. Tormen et al., who founded the start-up Thunder NIL in Padova, Italy, to promote this new way of ultrafast thermal imprint with heatable stamps. For the bottom-up approaches, “Capillary assembly

of cross-gradient particle arrays using a microfluidic chip” by S. Ni et al. presents a new process of producing structures with different densities on surfaces. The groundbreaking paper “Solid on liquid deposition, a review of technological solutions” by A. Homsy et al. covers a field rarely seen in MEE. These three examples are a good sign that MNE and consequently MEE’s “Micro/Nano Fabrication 2014” are covering both technological and exploratory papers. However, as often, they are complemented by more application-oriented papers in which these techniques are used. They can be found in other special issues of MEE, the high-end industrial applications, however, are found mainly in other conferences such as SPIE Alternative Lithographic Technologies.

Finally, we conclude that the “Micro/Nano Fabrication 2014” gives birth to potential new fields based on discoveries, research and development in the areas of scanning probe techniques and self assembly. Apart from this it seems that there is plenty of room for many combinations with more established lithographies to manip-

ulate materials and device building blocks. Surface nano engineering, nanomanipulation, integration of nano-objects, nanoscale modelling, molecular technologies, but also scale-up and transfer to manufacturing and multiscale manufacturing will open new avenues to the future of micro and nanofabrication.

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