Wednesday, 13th March 2019

08:30	**Registration** In front of room "Cobol" (coffee & snacks provided)	
09:00	**Welcome message** *Organizers*	
Session I	*An inspiring start: radically new ways to make working non-conventional computing devices*	Chair: Felix Holzner
09:10	**Perfect Patterning of Atomic Silicon Computational Elements** *Robert Wolkow, University of Alberta, Canada* Atomic circuitry composed of silicon surface dangling bonds have the potential to address the shortcomings of CMOS. Our circuitry consumes far less energy and can perform function not available with CMOS. An example of a unique application of the atomic circuitry will be described as well as how machine learning has been applied to automate our scanned probe fabrication tool. We now see no barrier to massively parallel, perfect, atom-scale fabrication and therefore to viable, commercial products.	
09:35	**Evolving functionality in disordered nanosystems** *Wilfred van der Wiel, University of Twente, Netherlands* We have shown that a designless network of gold nanoparticles can be evolved into Boolean logic gates. Now we demonstrate this principle in a nanoscale network of dopants in silicon, at much higher temperature. By exploiting the nonlinearity, we map a few inputs to a high-dimensional feature space, in which the data become linearly separable. We demonstrate MNIST digit recognition. Our approach illustrates the power of nanomaterial networks for solving complex computational tasks efficiently.	
10:00	**Break - coffee & snacks** Poster Area "Cobol"	
Session II	*Core NanoFrazor lithography: resists, pattern transfer and 3D (grayscale) applications*	Chair: Samuel Bisig
10:25	**Chemically amplified poly(olefin sulfone)s as promising resist material for thermal scanning probe lithography** *Christian Neuber, University of Bayreuth, Germany* Poly(olefin sulfone)s show very low ceiling temperatures and low thermal stabilities. This makes them promising candidates as new resists for t-SPL. The polymer with the lowest decomposition temperature of 180 °C, poly(2-methyl-1-pentene sulfone), could be patterned with similar sensitivity as compared to PPA. In a first test pattern 18.3 nanometer half-pitch lines were written. Additionally, we observed, that tetraalkylammonium salts reduce further the thermal decomposition temperature and that their etch resistance is improved by Al2O3 infiltration using ALD.	
10:50	**New materials for (high-resolution) pattern transfer** *Tero Kulmala, SwissLitho, Switzerland* NanoFrazor's ability to remove resist extremely locally enables the use of ultra-thin resist layers and most advanced multi-layer stacks for pattern transfer. Here, we introduce new, easy-to-use materials for accurate transfer of high-resolution NanoFrazor patterns. Ultrathin layers of spin-coatable silicon-rich hard mask used together with a highly cross-linked organic transfer layer (OTL) enable an efficient and robust pattern transfer process. New material choices and non-aqueous processing for the bilayer lift-off will also be presented.	
11:15	**Plasmonic Fourier Surfaces** *Nolan Lassaline, ETH Zurich, Switzerland* Periodically structured surfaces enable many key functionalities in photonics and plasmonics. Until now, it has not been possible to fully control the modulation of periodic surfaces due to limitations in the fabrication of grayscale surface topographies. Here, using thermal scanning probe lithography, we fabricate grayscale periodic plasmonic surfaces. We introduce a new type of optical surface, which we call a Fourier surface. We use the concept of Fourier surfaces to selectively tailor the optical properties of plasmonic surfaces for novel devices and experiments.	

11:40	**Break - coffee & snacks** Poster Area "Cobol"

Session III	*Novel methods to control the motion of particles in fluids*	Chair: Nils Goedecke

11:55	**High-resolution multi-channel nanoparticle separation with rocked Brownian motors** *Christian Schwemmer, IBM Research Zurich, Switzerland* Artificial Brownian motors were inspired by how nature achieves directed transport in highly diffusive environments. Brownian motors exhibit an Arrhenius-like onset of the particle current with increasing interaction energy which is a promising feature for particle separation. Using this property, we developed a fast and highly selective nanoparticle sorting device based on a rocked Brownian motor to separate gold spheres of 80 nm and 100 nm diameter into 30 subpopulations with < 2 nm resolution.
12:20	**Breaking symmetry to achieve propulsion at the microscale** *Lucio Isa, ETH Zurich, Switzerland* Breaking symmetry is at the core of microscale propulsion. Recently, we developed a new fabrication strategy to create micro-swimmers with full control on their geometrical and compositional asymmetry. The method exploits the sequential deposition of microspheres on topographical templates, where we independently define the swimmers' shape via the template, and we program their composition by fixing the deposition sequence. We then design and obtain particles that translate, rotate, switch between these two modes of motion and even perform drag-and-drop tasks.

12:45	**Lunch @ Technopark Cafeteria** coffee & snacks @ Poster Area "Cobol"
13:30	**NanoFrazor Demo** Group A meets at SwissLitho Laboratory

Session IV	*Thermally induced phase changes & Quantum sensing with diamond cantilevers*	Chair: Samuel Zimmermann

14:00	**Nanopatterning of GeTe phase change films via heated-probe lithography** *Adrian Podpirka, Johns Hopkins University Applied Physics Laboratory, USA* The crystallization of amorphous germanium telluride (GeTe) thin films is controlled with nanoscale resolution using the heat from a thermal AFM probe. The dramatic differences between the amorphous and crystalline GeTe phases yield embedded nanoscale features with strong topographic, electronic, and optical contrast. The flexibility of scanning probe lithography enables the width and depth of the features, as well as the extent of their crystallization, to be controlled by varying probe temperature and write speed. Together, these technologies suggest a new approach to nanoelectronic and opto-electronic device fabrication.
14:25	**Designing with spins: thermal nanolithography for spintronics and magnonics** *Edoardo Albisetti, Politecnico di Milano, Italy* Manipulating magnetism at the nanoscale is of paramount importance for developing next-generation devices for storage and processing. I will discuss the use of thermally assisted magnetic scanning probe lithography (tam-SPL) for creating multidimensional magnetic nanostructures with unprecedented properties, and realizing integrated nanomagnetic circuits for generating and manipulating spin-waves. These results pave the way to the realization of nanoscale platforms for beyond-CMOS magnetic computing.
14:50	**Nanoscale thermometry with single spins in diamond** *Patrick Maletinsky, University of Basel, Switzerland* Nitrogen-Vacancy (NV) center electronic spins in diamond yield powerful, nanoscale magnetometers, which have found application in nano-magnetism and beyond. Less known is the fact that NV spins can also be employed as sensors in thermal imaging or in-vivo temperature sensing. In my talk, I will give an introduction into the physics of NV centers and NV-based thermometry. I will make a connection to various approaches to quantum sensing that my group has developed over the years and give an outlook on the performance one might expect for future, NV-based nanoscale thermometers.

15:15	**Break - coffee & snacks** Poster Area "Cobol"

Session V	*Thermometry and fundamentals of nanoscale heat generation and heat flow*	Chair: Urs Dürig

15:40	**Nanoscale Thermometry with Thermal Probes** *Fabian Könemann, IBM Research Zurich, Switzerland* Beyond writing patterns, the thermal probes used in NanoFrazor technology have been shown to be capable of measuring heat fluxes with a sensitivity down to a single picowatt. This, together with the achievable single nanometer tip radius, makes them suitable for non-equilibrium thermometry with sub-ten-nanometer lateral resolution. We present further developments and applications of this technique. The results provide insight to electron phonon interactions in one-dimensional nanostructures.
16:05	**Heat dissipation non linearities in metallic nanostructures** *Alessandro Alabastri, Rice University, USA* The talk will provide an overview of the fundamentals and applications of plasmonics with particular focus on the role played by metallic nanostructures as efficient light-to-heat converters. In particular it will be explained how, through proper design, it is possible to realize plasmonic systems which exploit metals temperature dependent non-linearities to obtain unexpected optical responses.

16:30	**Apéro Tram through Zurich downtown to the Zoo Zurich** Special Tram leaves from the Station "Technopark" at 16:45 (direction Altstetten)
18:00	**Zoo Tour and dinner at the Elephant House** meeting at 17:50 at the main entrance of Zoo Zurich (no later entry possible)

SwissLitho AG
Innovative Nanofabrication Tools

IBM Research

Thursday, 14th March 2019

08:00	**Registration** In front of room "Cobol" (coffee & snacks provided)

Session VI	*Understanding tip wear & Potentially scalable AFM imaging techniques*	Chair: Philip Paul

08:30 **Atomic Scale Friction and Wear Using Heated AFM Tips**

Jonathan R. Felts, Texas A&M University, USA

As thermal atomic force microscopy requires solid contact at the hot tip, the mechanics of this sliding contact cannot be ignored. This talk details experimental studies of surface friction and thermally activated wear for heated tips under sliding conditions, demonstrating that environment, mechanics, and thermal transport are strongly linked.

08:55 **High throughput thermal lithography using optical beam deflection readout**

Klara Maturova, TNO Delft, Netherlands

The SwissLitho NanoFrazor tool is a powerful tool for maskless thermal scanning probe lithography at nanoscale. Within a collaborative project with SwissLitho, we have explored the feasibility for increasing throughput of the thermal lithography concept, by means of parallelization of scan heads, in order to make it suitable for industrial applications. In addition to this, to increase the bandwidth of the imaging process and to prevent possible sample damage, we demonstrated tapping mode imaging of patterned structures using low noise, high bandwidth optical readout of the cantilever.

09:20 **On-chip waveguide-coupled opto-electro-mechanical transducer for nanoscale displacement sensing**

Federico Galeotti, TU Eindhoven, Netherlands

The development of miniaturized nanoscale displacement sensors is becoming increasingly important in many fields. Here we present a nano-opto-electro-mechanical transducer for displacement sensing consisting of a double-membrane photonic crystal cavity integrated with electro-optical read-out and on-chip light-delivery. The on-chip integration of the sensing element is a key advantage in view of the development of parallel sensor arrays for high-throughput sensing and imaging.

09:45	**Break - coffee & snacks** Poster Area "Cobol"

Session VII	*Thermal transport measurements & Reaction kinetics for nanoscale phase changes*	Chair: Emine Cagin

10:10 **Advanced approaches for micro and nanoscale characterization of thermal transport properties in soft materials**

Junko Morikawa, Tokyo Institute of Technology, Japan

The micro-thermocouple recently developed consists of a gold and nickel thermocouple on a silicon nitride membrane and is miniaturized to the extent that the electrodes are 2.5 □m wide and the membrane is 30 nm thick. It shows sensitivity to temperature change, exhibiting high responsiveness to heat generated by a laser and an electron beam. Importantly, tiny temperature changes were measured by the developed thermocouple for both types of heating. Thermal diffusivity was determined using this sensor by detecting the phase shift of temperature wave induced by an electron beam irradiation.

10:35 **Micro-second heat pulses to induce phase changes by t-SPL**

Samuel Zimmermann, EPFL, Switzerland

In this work, the fast heating and cooling rates accessible by t-SPL are used on two organic thin film systems to locally induce phase changes in a transition dynamic that is not attainable at the macroscale. The first material is a fluorescent supramolecular polymer which exhibits a thermoresponsive luminescent behavior due to aggregation of excimer-forming moieties. The second material is silk fibroin, a polymorphic protein, which exhibits at least two different molecular structures with distinct water-solubilities.

11:00	**Break - coffee & snacks** Poster Area "Cobol"

Session VIII	*2D material devices*	Chair: ZhengMing Wu

11:25 **Engineering van der Waals Heterostructures: the importance of strain and superlattice effects**

Christian Schönenberger, University of Basel, Switzerland

2D van der Waals (vdW) materials like graphene (G) show excellent charge transport characteristics when encapsulated in between hBN. However, encapsulation, and in general all stacking of vdW layers, can change the electronic properties in a way not anticipated before. For example, hBN also imprints another potential modulation onto G given by the hBN lattice, giving rise to so-called Moiré superlattices (MSLs) with the result that "secondary Dirac points" (sDP) emerge in the bandstructure. Further, strain can also change the bandstructure. Today, the research community tries to make use of the many different ways vdW materials can be stacked with the goal to engineer the combined electronic properties.

11:50 **Controlling Electronic Properties of Correlated Two-Dimensional Materials**

Yijun Yu, Fudan University, China

Vast opportunities exist in correlated Two-dimensional (2D) materials: they feature a number of exotic phenomena such as high-Tc superconductivity and magnetism. However, many of these materials are very sensitive. The fabrication process is the major obstacles to study them. Here I will introduce the fabrication technique we developed in Prof. Yuanbo Zhang's group and the interesting results we obtained on 2D magnet Fe_3GeTe_2 and 2D superconductor $Bi_2Sr_2CaCu_2O_8$+x. We will also show our recent progress on device fabrication by NanoFrazor.

12:15 **Record breaking 2D material transistors**

Xiaorui Zheng, Swinburne University, Australia

We demonstrate back- and top-gated field-effect transistors on epitaxial and exfoliated MoS_2 and WSe_2 monolayers with exceptional performances which have never been realized before. This proves the NanoFrazor to be an outstanding platform with clear superiorities over any other nanolithography method for manufacturing of 2D devices.

12:40 **Lunch @ Technopark Cafeteria**
coffee & snacks @ Poster Area "Cobol"

13:30 **NanoFrazor Demo**
Group B meets at SwissLitho Laboratory

Session IX	*2D material devices & direct write optical lithography for industrial applications*	Chair: Tero Kulmala

14:00 **Atomic scale patterning in 2D materials**

Tim Booth, DTU Copenhagen, Denmark

Taking advantage of the increasing availability of an ever widening array of 2D materials means we need to pattern these materials at the finest scales, down to the level of a few atoms. I will discuss techniques for this, the dominating impact of edge disorder, fundamental limits imposed on patterning due to the discrete statistics of atom-by-atom removal, and perspectives for scanned probe patterning of matter at the ultimate resolution.

14:25 **Direct patterning of p-type-doped few-layer WSe_2 nanoelectronic devices by oxidation SPL**

Yu Kyoung Ryu Cho, Instituto de Ciencia de Materiales de Madrid (CSIC), Spain

A thin self-limited oxide layer is formed on top of a few-layer WSe_2 flake by applying an oxygen plasma treatment. This oxide layer has a double role in our work. First, it introduces a p-doping effect in the electronic device. Second, it enables the patterning of oxide nanoribbons with controlled width and depth by oxidation scanning probe lithography. Applying this process, we present the fabrication of a 5 nm thick WSe_2 field-effect transistor, with a channel consisting in an array of 5 parallel 350 nm half-pitch nanoribbons.

14:50 **From semiconductor reticle fabrication to high-resolution maskless applications: Laser lithography using high-speed light modulators at sub-micron resolution**

Achim Jehle, Heidelberg Instruments, Germany

Semiconductor photomasks (reticles) require tight specifications for CD control, pattern placement accuracy and pattern fidelity. Heidelberg Instruments builds lithography systems for reticle writing featuring an i-line laser, a high-speed spatial light modulator and precision optics. This technology has become very interesting for maskless applications, prototyping IC and MEMS, wafer-level packaging and many other applications where precision down to 500nm feature size and overlay, CD uniformity and line edge roughness better than 50 nm (3σ) matter.

15:15	**Break - coffee & snacks** Poster Area "Cobol"	
Session X	*3D printing at the micro- and nanoscale*	Chair: Armin Knoll
15:40	**3D µ-printing - An enabling technology** *Georg von Freymann, Technical University Kaiserslautern, Germany* 3D µ-printing based on two-photon absorption laser lithography is a widespread technology found in different fields as biology, materials research, photonics, micro-optics just to name a few. I will report on latest technological advances like STED-inspired SLM based lithography and present some application examples from different fields.	
16:05	**High-resolution nanoprinting by local surface reactions using finely focused electron probes** *Ivo Utke, Empa, Switzerland* Finely focused electron beams in scanning electron or in scanning tunnelling probe microscopes are routinely used to visualize nanometre-sized objects. But add chemistry and they can do much more on the nanometre scale! When adding volatile functional gas molecules into the game, they form continuously renewing physisorbed monolayers on substrates which allow for 2D and 3D direct writing of functional material. We will review the basic principles of these minimally invasive, maskless, direct write approach together with applications in nanosciences & industry realized so far.	
16:30	**Additive Nanodevice Fabrication Using a Heated AFM Tip** *Huan Hu, Zhejiang University, China* This talk will introduce an additive method of using a heated atomic force microscopic tip for fabricating nanodevices. Molten polymer nanostructures are printed by the heated AFM tip and later are used as etching masks for transferring the structures to functional materials such as silicon and graphene. Various nano-devices such as mechanical nano-resonators, nanofluidic channels, optical gratings, graphene transistors are demonstrated. This tip-based approach is a low-cost and versatile prototyping technology for nanodevices.	
16:55	**Closing Remarks**	
17:00	End of the official program	

Posters

Posters will be put up at the walls in the conference room Cobol. You are welcome to bring along your poster also without prior notice. The following posters registered:

Dilek Yildiz	Energy dissipation via image potential states on Bi2Te3 surface
Robert Kirchner	Anisotropic 3D wet etching of silicon dioxide using a metal mask and hydrofluoric acid
Bojun Cheng	Atomic scale memristor with thermal scanning probe patterned 3D tip