How to implement “nano” in everyday life? Nano fabrication technologies in application oriented research and development

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Nano fabrication technologies and nano technologies at least are subject of research in several fields but mainly invisible, still. The development and commercialization of nano-inside products next to powders, inks and microelectronics are still waiting for its break through and wide acceptance. However, this paper will describe three examples of research work with implemented and integrated nano patterns and new functionality in fields of bio-inspired computing, nano patterned surfaces for flexible substrates, and nano optics for spectroscopic measurement.

Within a joint project between Fraunhofer ENAS and the Karlsruhe Nano and Micro Facility at Karlsruhe Institute of Technology, the micro- and nano-structuring of biocompatible materials is investigated. Doing so and in order to adapt natural adhesive structures such as Gecko feet, Parylene is patterned into micropillars using hot-embossing. Intended applications for these structures are medical wearables that can measure vital signals or other flexible electronics that can be attached to the skin or other surfaces without any chemical adhesive, which could irritate the skin or leave residues on the surface (Fig.1).

Nano systems technology based on the combination of conventional semiconductor processing with biotechnological approaches is an emerging field with manifold applications. The idea of "network-based biocomputation"[1] is that small biological agents, each of which is only a few nanometers in size and driven by biomolecular motor proteins, can solve mathematical problems when finding their way through a nano-lithographically fabricated network of micro and nano-fluidic channels. The nano-channel networks are designed to represent a solution space for a particular mathematical problem. Therefore, besides patterning of the nano-channels by e-beam lithography, functional elements like junctions, tagging areas, multiplication of agents, detectors and a microfluidic environment is necessary. Implementing error free junctions requires the third

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[1] In the EU project Bio4Comp Fraunhofer ENAS together with Fraunhofer ICS, BCube of TU Dresden, Nanolund of Lund University, the Linneaus University in Kalmar, the Bar Ilan University as well as Molecular Sense Ltd. work on such nano system technologies for developing "network-based biocomputation".

dimension for realizing over- and underpasses. Detectors can be realized by integrating single CNT transistors as capacitive sensors. For running, the biocomputers motorproteins like myosin or kinesin have to be locally immobilized to obtain the agent transport in the nano-channels itself. A fluid containing protein filament agents and ATP as the fuel brings the biocomputer to life (Fig. 2).

Miniaturized spectrometry systems such as Fabry-Pérot Interferometers (FPI) for different wavelength ranges enable new breakthrough application scenarios like infrared spectrum analysis of substances and gases e. g. in an online monitoring system. The basic approach for such a system is based on an optical resonator, which is formed by two reflectors together with the optical cavity. At least one of the reflectors is movable in order to adjust the distance between the reflectors. Thus, the FPI becomes tunable. Most of the reflectors consist of alternating layers stacks by using H-layers with a higher refractive index and L-layers with a lower refractive index and/or by using a larger number n of the layer pairs $(HL)^n$. We present two adequate approaches for sub-wavelength gratings (SWG) reflectors based on 6" wafer level nanotechnologies (e-beam- and nano imprint lithography) as alternative to the $(HL)^n$ reflectors (Fig. 3).

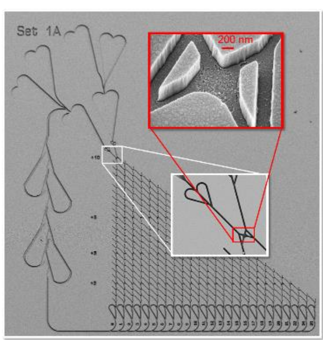

Fig. 1: SEM picture of a nano-channel network working as a biocomputer for solving NP complete problems.

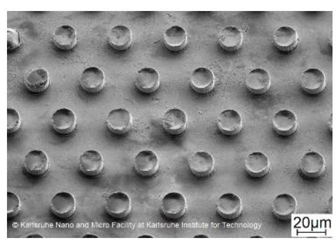

Fig. 2: Hot embossed Nano Patterns in Parylene Layer (in cooperation with KIT).

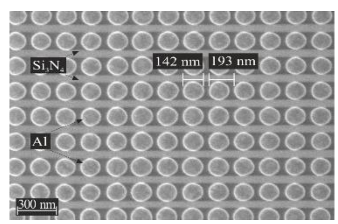

Fig. 3: SEM image of a manufactured SWG reflector (50 nm thin Al-structures on 200nm thin LP-Si3N4 membrane