O 76: Nanostructures at surfaces IV

Time: Thursday 16:00–17:30 Location: MA 042

O 76.1 Thu 16:00 MA 042

Silicon micro-tip arrays for fast-switchable cold electron sources — •Pavel Serbun[1], Aliaksandr Navitski[1], Benjamin Bornmann[1], Stephan Mingels[1], Günter Müller[1], Florian Dams[2], Christian Prommesberger[2], and Rupert Schreiner[2] — [1]FB C Physics Department, University of Wuppertal, 42119, Wuppertal, Germany — [2]Faculty of Microsystems Technology, University of Applied Sciences Regensburg, Germany

Silicon-based cathodes with precisely aligned field emitter arrays applicable for miniaturized electron sources were successfully fabricated. The cathode chips contain about 3x10^5 Si tips/cm^2 in a triangular array with a tip height of 1 or 2.5 um, tip radius of about 20 nm, and 20 um pitch. Amazingly homogeneous and well-aligned field emission (FE) from all tips (100% efficiency) and maximum stable currents of about 0.1 uA for p- and 0.6 uA for n-type Si were reproducibly achieved. Additional coating with a bimetallic layer (5 nm Cr and 10 nm Au) resulted in at least 5 times higher average FE current i.e. typically 3 uA but lead, however, to a 30% increase of the onset voltage. I-V characteristics of p-type Si tips exhibit the expected I-V characteristics consisting of a linear FN-like part at low field/current, a current saturation region, and finally a rapid current rise at high field due to secondary charge effects. Moreover, a high photosensitivity of the saturation current was observed which provides a unique possibility to modulate the electron current by ultra-short light pulses. Detailed FE and light-modulation results of p-type arrays of varying size and tip-number will be presented and discussed at the conference.

O 76.2 Thu 16:15 MA 042

Photo sensitivity and field emission properties of B-doped Si-tip arrays — •Benjamin Bornmann[1], Stephan Mingels[1], Aliaksandr Navitski[1], Pavel Serbun[1], Florian Dams[2], Christian Prommesberger[2], Rupert Schreiner[2], Dirk Lützenkirchen-Hecht[1], and Günter Müller[1] — [1]FB C Physics Department, University of Wuppertal, 42119, Wuppertal, Germany — [2]Faculty of Microsystems Technology, University of Applied Sciences Regensburg, 93053, Regensburg, Germany

Field emission (FE) cathodes have shown significant advantages over thermionic electron sources. For sensor applications Si tips are favored because they can be easily integrated with other Si based components. p-semiconductors have a limited number of free electrons thus being highly sensitive to photonic excitation. This allows the realization of compact fast switchable e^--sources. We report on FE-spectroscopy on B-doped Si-tip arrays with optional tunable laser illumination (0.5-5.9 eV). The current-voltage curve exhibits three emission regimes: a Fowler-Nordheim regime at low currents, a saturation region due to electron depletion and secondary carrier generation at high currents. The corresponding spectra show an increased charging in saturation by a shift and splitting of the peaks. A high conductivity is observed under secondary carrier generation. The FE is most stable in saturation as the emission strongly depends on the supply function here rather than on the surface sensitive tunneling probability. Accordingly, the highest photosensitivity is observed in saturation. Optimization of the quantum efficiency with tunable laser illumination is ongoing.

O 76.3 Thu 16:30 MA 042

Template-based surface nano-patterning to realize high performance devices — •Liaoyong Wen, Huaping Zhao, Fabian Grote, Yan Mi, Ranjith Vellacheri, Zhibin Zhan, Ahmed Al-Haddad, Yaoguo Fang, Kin Mun Wong, and Yong Lei — Fachgebiet 3D-Nanostrukturierung, Institut für Physik & ZIK MacroNano, Technische Universität Ilmenau, 98693 Ilmenau, Germany

Surface patterning using nano-templates are highly efficient in preparing large-scale ordered arrays of surface nanostructures. Here we introduce surface patterning processes using two templates that are prepared using self-assembly processes: ultra-thin alumina membranes (UTAMs) and monolayer polystyrene (PS) sphere arrays. The surface patterns have promising device applications due to the low-cost and time-saving fabrication processes of surface structures. The feature size of the building blocks of the surface patterns prepared using UTAM and PS templates can be adjusted from the quantum size to the nanometer size and to the micrometer size range. Different functional surface nano-patterns have been developed using the UTAM and PS templates, including 1D nanostructure arrays, quantum-sized nanodot arrays, and metallic hollow sphere arrays. The device applications in photocatalytic devices, supercapacitors, solar cells, SERS sensors, and field emission device will be demonstrated.

1.Lei, Y.; Yang, S. K.; Wu, M. H.; Wilde, G., Chem. Soc. Rev. 2011, 40, 1247. 2.Yang, S. K.; Xu, F.; Ostendorp, S.; Wilde, G.; Zhao, H.; Lei, Y., Adv. Funct. Mater. 2011, 21, 2446. 3.Wu, M. H.; Wen, L. Y.; Lei, Y.; Ostendorp, S.; Chen, K.; Wilde, G., Small 2010, 6, 695.

O 76.4 Thu 16:45 MA 042

Magnetic nanowire arrays prepared by electrodeposition using AAO templates — •Nina Winkler, Jörn Leuthold, Martin Peterlechner, Yong Lei, and Gerhard Wilde — Institute of Materials Physics and Center for Nanotechnology, University of Münster, 48149 Münster, Germany

Regular magnetic nanowire arrays with large wire aspect ratios have possible applications, amongst others, in high density magnetic recording media and biological sensing of carbohydrates. Porous Anodic Alumina Oxide (AAO) is a versatile template for surface nanostructuring and in this talk, the fabrication of nanowire arrays by electrodeposition using AAO will be addressed. The AAO template enables control of regularity and shape of nanostructures by its pores which are hexagonally arranged and stand perpendicularly on an Aluminum substrate. Two different pretreatments of the AAO template will be presented to either remove or perforate the insulating alumina barrier layer between Al substrate and pores of the AAO template. Electrodeposition is applied using a potential pulse sequence to obtain nickel, iron, cobalt or FeNiP nanowire arrays. The structure of the nanowire arrays has been observed by SEM and TEM. The magnetic properties of the nanowire arrays have been characterized by Vibrating Sample Magnetometer (VSM) measurements and Magnetic Force Microscopy (MFM). The high regularity of a nanowire array is demonstrated using an image-based analysis tool which compares the arrangement of the wires to a mathematically perfect hexagonal pattern and therefore allows a quantitative analysis of the hexagonal regularity of the nanowire array.

O 76.5 Thu 17:00 MA 042

Highly sensitive gas sensors based on three-dimensional surface nano-patterns realized by UTAM nano-structuring technique — •Yan Mi[1,2], Zhibin Zhan[1,2], Hui Sun[1,2], Fabian Grote[1,2], Huaping Zhao[1,2], and Yong Lei[1,2] — [1]Fachgebiet 3D-Nanostrukturierung, Institut für Physik & Zentrum für Mikro- und Nanotechnologien (ZIK MacroNano), Technische Universität Ilmenau, 98693 Ilmenau, Germany — [2]Institut für MaterialPhysik, Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

Using an innovative three-dimensional (3D) surface nano-structuring technique, highly ordered functional surface nano-patterns can be synthesized with high application potentials. In this talk, we demonstrate an excellent device application of the 3D surface nano-patterns - gas sensors with extremely high sensitivity. The basic structures of the high sensitive gas sensors are template-prepared ZnO nanotube arrays via atomic layer deposition process. The sensitivity of the gas sensor to NO2 gases could reach 25 ppb level, which has not been reported before for commercial gas sensors. Such kind of high sensitivity to NO2 is quite attractive to environmental protection and atmospheric quality monitoring. The high regularity and controllability to the structural parameters of the 3D nano-patterns make it possible to investigate the surface chemistry and physics of the gas sensors and hence to optimize the device performance.

O 76.6 Thu 17:15 MA 042

High performance super-capacitors based on template-prepared one-dimensional MnO_2 nanostructures — •Fabian Grote[1,2], Yan Mi[1,2], Huaping Zhao[1,2], and Yong Lei[1,2] — [1]Institut für Physik & Zentrum für Mikro- und Nanotechnologien, Technische Universität Ilmenau, Germany — [2]Institut für Material Physik, Westfälische Wilhelms-Universität Münster, Germany

MnO_2 is a promising candidate for future applications in high performance super-capacitors, since it possesses a high specific capacitance. A way of selectively control the growth of highly ordered MnO_2 nanowire and nanotube arrays for fabricating a super-capacitor electrode will be demonstrated using an electrochemical deposition tech-

nique in combination with porous aluminium oxide as a template. The morphology is investigated by field emission scanning electron microscopy and transmission electron microscopy. Electrochemical properties of different structures will be shown and compared.