NANO WIRES (SYNW)

Jointly organized by
Thin Films (DS)
Semiconductor Physics (HL)
Metal and Material Physics (MM)
Surface Physics (O)
Low Temperature Physics (TT)

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OVERVIEW OF INVITED TALKS AND SESSIONS

(lecture room HSZ 04)

Invited Talks

SYNW 1.1	Wed	14:00	(HSZ 04)	**Electrodeposition and Functional Properties of Metal Nanowires**, Reginald M. Penner,
SYNW 1.2	Wed	14:30	(HSZ 04)	**Quantum coherent transport in semiconductor nanowires**, Silvano De Franceschi, Jorden van Dam, Yong-Joo Doh, Leo Kouwenhoven, Aarnoud Roest, Erik Bakkers
SYNW 1.3	Wed	15:00	(HSZ 04)	**In situ Transmission Electron Microscopy Studies of Vapor-Liquid-Solid Phase Growth of Si Nanowires**, S. Kodambaka, J. B. Hannon, J. Tersoff, M.C. Reuter, R.M. Tromp, F.M. Ross
SYNW 2.1	Wed	16:00	(HSZ 04)	**Quantum devices based on heterostructure semiconductor nanowires**, Claes Thelander
SYNW 2.2	Wed	16:30	(HSZ 04)	**ZnO nanowires and naowire arrays: controlled growth and microscopic characterizations**, Hongjin Fan
SYNW 2.3	Wed	17:00	(HSZ 04)	**Electrically-Driven Nanowire Devices for Sensors and Photonics**, Oliver Hayden

Sessions

SYNW 1	**Symposium: Nano-Wires I**	Wed 14:00–15:30	HSZ 04	SYNW 1.1–1.3
SYNW 2	**Symposium: Nano-Wires II**	Wed 16:00–17:30	HSZ 04	SYNW 2.1–2.3

Sessions

– Invited Talks –

SYNW 1 Symposium: Nano-Wires I

Time: Wednesday 14:00–15:30 Room: HSZ 04

Invited Talk SYNW 1.1 Wed 14:00 HSZ 04

Electrodeposition and Functional Properties of Metal Nanowires — •Reginald M. Penner and — Department of Chemistry, University of California, Irvine, CA 92697-2025 USA

Semiconductor nanowires can be used as transducer to detect the binding of charged analyte molecules. However in view of the frenzied pace of research relating to nanowires synthesis, remarkably few publications report advances in semiconductor nanowire-based sensing. Progress in this direction has been impeded by the intrinsic instability of semiconductor nanowires toward corrosion.

Noble metal nanowires are attractive candidates for chemical sensing. However, in contrast to semiconductor nanowires, the conductivity of metal nanowires is not expected to be responsive to 'charge gating'. We have developed a new method for preparing arrays of noble metal nanowires that involves the electrodeposition of metals onto stepped graphite surface and the transfer of arrays of wires onto glass surfaces using a simple embedding process. These transferred nanowires form the basis for chemical sensors in which the resistance of the nanowire array is modulated by molecules that chemisorb at the surface. Two examples involve palladium nanowires in the presence of hydrogen, and silver in the presence of amines. For both systems, the changes in resistance ($\triangle$R/R0) can be 1000.

What is the origin of these unexpected resistance changes? We focus attention on this issue and we discuss the prospect for developing practical chemical sensors based on these novel mechanisms.

Invited Talk SYNW 1.2 Wed 14:30 HSZ 04

Quantum coherent transport in semiconductor nanowires — •Silvano De Franceschi[1], Jorden van Dam[2], Yong-Joo Doh[2], Leo Kouwenhoven[2], Aarnoud Roest[3], and Erik Bakkers[3] — [1]CNR TASC-INFM, Trieste, Italy — [2]Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands — [3]Philips Research Laboratories, Eindhoven, The Netherlands

Much of the recent interest for chemically grown semiconductor nanowires arises from their huge versatility which translates into a wide range of potential applications. Many important proofs of concept have already been provided such as field effect transistors, elementary logic circuits, resonant tunneling diodes, light emitting diodes, lasers, and biochemical sensors. These achievements, together with the recent advance in the monolithic integration of III-V nanowires with standard Si technology, may open the way to the development of next-generation (opto)electronics. On the other hand, the high degree of freedom in nanowire growth and device engineering creates new opportunities for the fabrication of controlled one-dimensional systems for low-temperature applications and fundamental science. Here I will present an overview of this emerging field with an emphasis on the electronic transport properties of III-V nanowires. In particular I will report on single-electron transport, quantum confinement, and the recent observation of a tunable Josephson effect in superconductor-nanowire-superconductor devices.

Invited Talk SYNW 1.3 Wed 15:00 HSZ 04

In situ Transmission Electron Microscopy Studies of Vapor-Liquid-Solid Phase Growth of Si Nanowires — •S. Kodambaka, J. B. Hannon, J. Tersoff, M.C. Reuter, R.M. Tromp, and F.M. Ross — IBM T.J. Watson Research Center, Yorktown Heights, NY 10598

Using ultra-high vacuum transmission electron microscopy (UHV-TEM), we study the growth kinetics of Si nanowires. Wires are grown in situ on Au-covered Si(111) substrates using disilane ($P_{Si2H6} = 10^{-6}$ Torr) at temperatures between 500 and 700oC. We observe, in real-time, the growth of ¡111¿-oriented Si wires in the presence of molten Au-Si eutectic droplets serving as the catalysts. From the TEM images of individual Si wires, acquired at video rates, we measure time-dependent changes in lengths and diameters of the wires and volumes of the Au-Si droplets. We find that the lengths of all wires increase linearly with deposition time at a temperature-dependent constant rate that is independent of the droplet diameter. Volumes of all the droplets decrease with time during both deposition and annealing in vacuum. We attribute this behavior to loss of Au due to Ostwald ripening of droplets on top of wires and incorporation on wire surfaces. We find that presence of small amounts of O_2 during growth prevents loss of Au from the droplets and favors the growth of ¡110¿-oriented Si wires. Our results provide insights into mechanisms governing the kinetics of Si nanowire growth.

SYNW 2 Symposium: Nano-Wires II

Time: Wednesday 16:00–17:30 Room: HSZ 04

Invited Talk SYNW 2.1 Wed 16:00 HSZ 04

Quantum devices based on heterostructure semiconductor nanowires — •Claes Thelander — Solid State Physics, Lund University, 221 00 Lund, Sweden

Epitaxial growth of heterostructure InAs/InP semiconductor nanowires will be described. Fabrication of Ohmic contacts to such nanowires allows investigation of their transport characteristics. We observe that thin InAs nanowires experience strong radial quantum confinement and are depleted of charge carriers, whereas thicker wires are almost metal-like. A few quantum-based devices realized in the InAs/InP heterostructure system will be presented. Growth of a short (10 nm) InAs dot section between two InP tunnel barriers results in very strong quantum confinement along the axial direction. Filling such a dot with ~20 electrons only involves the ground state in the axial direction, and clear shell filling effects are observed due to spin and orbital degeneracies in the radial directions. We also investigate electron transport in multiple tunnel junction devices. It is demonstrated that electrons can be stored in meta-stable states in a tunnel junction-based nanowire memory containing up to 10 InP barriers. Memories based on electron tunneling are predicted to have considerable faster write speeds than corresponding devices relying on thermionic emission over a barrier.

Invited Talk SYNW 2.2 Wed 16:30 HSZ 04

ZnO nanowires and naowire arrays: controlled growth and microscopic characterizations — •Hongjin Fan — Max Planck Institute of Microstructure Physics, 06120 Halle, Germany

Semiconductor nanowires (NW) are promising building blocks for nanoscale electronic and optical devices. For this, controlled synthesis and microscopic characterization of the physical properties of the NW are in the center of current research. In this talk the growth of ZnO NW and NW arrays will be presented. The successful fabrication of periodically arranged ZnO NW is achieved by combining substrate patterning and the catalyst-directed vapor-liquid-solid growth. Various kinds of templating methods have been used including metal nanotube membranes and self-assembled nanosphere mask. We demonstrate the control of position, diameter, length, and orientations of the NW.

The single-crystallinity and epitaxial growth of ZnO NW arrays are verified by cross sectional TEM analysis. Microscopic characterization of individual NW are undertaken using micro-PL spectroscopy to assess the optical quality and study stimulated emissions, scanning cathodoluminescence to identify spatial origin of luminescence and bending effect, and piezoresponse force microscopy to measure the effective piezoelectric coefficient. In addition, we will show the in-situ manipulation of the NW using SEM-based nanotips.

Invited Talk SYNW 2.3 Wed 17:00 HSZ 04

Electrically-Driven Nanowire Devices for Sensors and Photonics — •Oliver Hayden — Department of Chemistry and Chemical Biology, Harvard University, Cambridge, MA 02138, USA, current address: IBM Research GmbH, Zurich Research Laboratory, CH-8803 Rueschlikon, Switzerland

Semiconducting nanowires are one of the most promising low dimensional materials for the bottom-up fabrication of nanodevices. The application of photonic and electrical devices from silicon and cadmium sulphide nanowires is presented. Ion-sensitive field effect transistors are formed with silicon nanowires and nanotubes, which allow label-free observation of immunological reactions with single virus sensitivity. Nanoscale light emitting diodes are integrated in microfluidic channels and used as intrinsically confocal light sources. These LEDs were applied to demonstrate single analyte detection and cellular imaging. The additional integration of nanowire avalanche photodiode detectors allows even optoelectronic coupling on the nanoscale.