TUT 2: Tutorial: Integration and Modelling of Nanoelectronic Components (DS)

The development of novel nanoelectronic components, e.g. semiconductor nanowires, single organic molecules or magnetic nanoparticles, aims at the creation of electronic circuits at the smallest possible length scale. A first prerequisite for the construction of such electronic components is the formation of a reliable, electrical contact to the electrically active parts and their integration into larger networks. This can be achieved either by self organization or by novel lithography methods. Reliable circuits can only be built if effects arising from transport through individual nanostructures as well as collective effects caused by the integration of the nanostructures into larger networks are well understood and controlled. This tutorial will provide an overview on the experimental realization of the contacts, modeling of the systems, and possible schemes for the development of larger circuits. The introductory talks in this tutorial will be presented by members and collaborators of the International Helmholtz Research School NanoNet, which deals with the development of nanoelectronic circuits.(Organizer: Artur Erbe, Helmholtz-Zentrum Dresden-Rossendorf)

Time: Sunday 16:00–18:15 Location: H3

Tutorial TUT 2.1 Sun 16:00 H3

Current transport through nanoscale electronic components — •Artur Erbe — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The semiconductor industry has been scaling down electronics in the course of the past decades. It is clear that at the current speed of miniaturization fundamental limits will restrict the further development of nanoelectronics. Therefore, alternative ways for building electronics need to be developed. Possible candidates for active nanoelectronic building blocks are single organic molecules or metallic nanoparticles. The first step in building electronic circuits from these single components is the definition of a reliable contact to external connections. In this talk an overview on contacting schemes will be given and their advantages and problems will be discussed. Typical results, which have been found on single molecules and metallic nanoparticles using these techniques, will be presented. These facts clearly show that nanoelectronic components for future electronic are already being developed and that the next step in these developments will be the interconnecting of these single building blocks in order to produce integrated circuits.

Discussion (5 min)

Tutorial TUT 2.2 Sun 16:35 H3

Theory of electronic transport in single-molecule junctions — •Juan Carlos Cuevas — Departamento de Fisica Teorica de la Materia Condensada, Universidad Autonoma de Madrid, E-28049 Madrid (Spain)

The recent advancements in nanofabrication techniques have allowed to contact individual molecules between metallic electrodes and to investigate their transport properties. This has posed a formidable challenge for the theory, namely to elucidate the physical mechanisms that dominate the electronic conduction at the nanoscale. In this talk I will briefly review some of the theoretical techniques and tools that are currently being used to describe the transport properties of single-molecule junctions, and I will discuss the novel transport phenomena that occur in these systems.

Discussion (5 min)

Tutorial TUT 2.3 Sun 17:10 H3

DNA-programmed assembly of dendrimers and conjugated polymers — •Kurt Gothelf — Aarhus University, Aarhus, Denmark

The idea behind our research is to use DNA as a programmable tool for directing the self-assembly of molecules and materials. The unique specificity of DNA interactions, our ability to code specific DNA sequences and to chemically functionalize DNA, makes it the ideal material for controlling self-assembly of components attached to DNA sequences. We have developed some new approaches in this area such as the use of DNA for self-assembly of organic molecules[1] and position dendrimers. We have used DNA origami to assemble organic molecules, study chemical reactions with single molecule resolution [4]. We have also formed 3D DNA origami structures [5] and dynamic DNA structures [6]. In the presentation I will focus on our recent progress on self-assembly of macromolecular DNA conjugates such as dendrimers and conjugated polymers into DNA origami.

References [1] Ravnsbaek; J. B et al. Angew. Chem. Int. Ed. 2011, 50, 10851-10854. [3] Liu, H. et al. J. Am. Chem. Soc. 2010, 132, 18054-18056. [4] Voigt, N. V. et al. Nature Nanotech. 2010, 5, 200-205. [5] Andersen, E. S. et al. Nature 2009, 459, 73-76. [6] Zhang, Z. et al. Angew. Chem. Int. Ed. 2011, 50, 3983-3987.

Discussion (5 min)

Tutorial TUT 2.4 Sun 17:45 H3

Silicon Nanowires: A Versatile Technology Platform for Nanoelectronic Research — •Thomas Mikolajick[1,2], Andre Heinzig[2], Jens Trommer[1], Dominik Martin[1], Matthias Grube[1], Andreas Krause[1], and Walter Weber[1] — [1]NaMLab GmbH, Nötnitzer Strasse 64, 01187 Dresden — [2]Chair for Nanoelectronic Materials, TU Dresden, Nötnitzer Strasse 64, 01187 Dresden

Silicon nanowire based metal insulator silicon (MIS) devices offer the best gate control and therefore will enable the ultimate scaling of CMOS devices. Moreover, the specific features of a very precise controlled structure and the quasi 1-dimensional geometry (transport) make silicon nanowires an ideal platform for new device concepts like junctionless devices or tunnel field effect transistors. Recently, the reconfigurable field effect transistor (RFET) [1] using the unique properties of silicon nanowires [2] enables the electrical configuration of n- or p-type behavior. In this talk the technology as well as the device properties of the RFET will be explained. It will be shown that the same basic structure can successfully be applied to realize chemical and biochemical sensors. Finally, additional examples of the application of the base technology in anodes for Li-ion batteries will be given. [1] A. Heinzig, et al. Nano Lett. 12, 119 (2012) [2] D. Martin et al. Phys. Rev. Lett. 107, 216807 (2011)