MESA+
INSTITUTE FOR NANOTECHNOLOGY
NANOELECTRONICS.

NANOELECTRONICS GROUP

WHERE THE FUTURE IS BEING MADE TODAY

Nanoelectronics comprises the study of the electronic and magnetic properties of systems with critical dimensions in the nanoregime, i.e. below 100 nm. Hybrid inorganic-organic electronics, spin electronics and quantum electronics form important subfields of nanoelectronics.

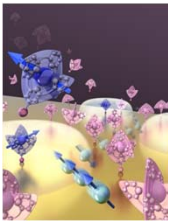
The research goes above and beyond the boundaries of traditional disciplines, synergetically combining aspects of electrical engineering, physics, chemistry, materials science, and nanotechnology

Hybrid inorganic-organic electronics

Hybrid inorganic-organic electronics

Where conventional electronics makes use mainly of top-down fabrication technology, the intro-duction of molecular materials paves the way for bottom-up fabrication as well (self-assembly). Hybrid inorganic-organic electronic devices benefit from the strong aspects of both fabrication methods. In this research line we take advantage of all these characteristics of hybrid electronic devices to carry out experiments in a largely unexplored area of fundamental and broad scientific interest.

The conduction mechanism in organic (molecular) materials often differs drastically from that in their inorganic (crystalline) counterparts, and still many aspects remain to be understood. A very important and critical issue is the understanding of electronic phenomena at the interface between inorganic and molecular materials, as they usually play a dominant role in the overall properties.

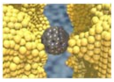


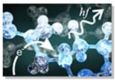
Coherent transport properties of organic molecules

Although coherent electron transport in inorganic systems is experimentally well studied, the coherence of electron transport through organic molecules is experimentally much less explored. It is a fascinating question to what extent transport through organic molecules is coherent and how the coherence depends on the molecule's characteristics, as well as on external parameters. Our objective is a study of coherence in molecular systems.

Electronic characterization of single nanostructures

Connecting single nanostructures to electric circuitry has proven to be an extremely difficult task. Our objective is to develop an unconventional bottom-up nanocontacting scheme for addressing single nanostructures for the goal of single-electron/photon control. The nanostructures are attached by self-assembly to conductive leads, bridging the gap between the nano- and microscale.





Organic spintronics

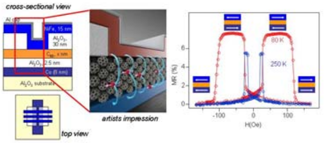
Controlling and probing charge carrier spin polarization in semiconductors via electrical means is an attractive route towards the development of practical semiconductor spintronic devices, which are expected to have a strong impact on future information processing and storage technologies.

Organic semiconductor spintronics

carbon-based, organic semiconductors offer a number of unique advantages for spintronics, in particular because spin lifetimes are potentially very long. We study spin polarized charge transport in organic spintronic devices, by electronic measurements in magnetic fields, from room temperature down to cryogenic temperatures.

Organic spin valves

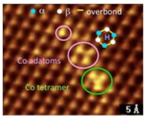
A spin valve, as shown in the picture above/right, can be "opened" (low resistance) and "closed" (high resistance) by flipping the magnetization of the ferromagnetic electrodes. This principle is used in commercial magnetic field sensors, for example hard disk read heads, and RAM elements. Using (organic) semiconductors offers many more possibilities, since the spins of the carriers may be manipulated via external electric/magnetic fields. We investigate how this manipulation can be done best.



Left: Cross section and top view of a C60-based vertical organic spin valve fabricated by vapor deposition and shadow masking to obtain a cross-bar geometry.
Right: magnetoresistance measurements of a spin valve comprising a 5 nm C60 layer.

Ferromagnetic/organic interfaces

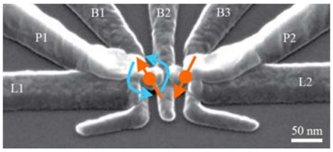
Interfaces are crucial in spintronics. We use a wide range of techniques, such as STM and synchrotron radiation methods, to study interfacial properties. The example to the right shows STM analysis of the nucleation of few-atom Co clustes on graphite.



Silicon quantum electronics

Silicon quantum electronics studies the quantummechanical behavior of isolated electrons in silicon. We confine single electrons in quantum dots, and probe their spin states in transport measurements at low temperatures.

With our research we want to gain a better understanding and control of quantum systems with future applications such as a quantum computer.



Scanning Electron Microscope image of a silicon double quantum dot in a nanoMOSFET structure. Aluminium gate electrodes on a silicon substrate define two quantum dots at the interface of Si and SiO_2. We isolate single electrons in both dots and try to control their spin states.

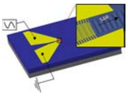
Spin quantum bits in silicon quantum dots

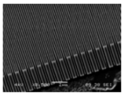
We aim at controlling the spin states of individual electrons in silicon double quantum dots with the ultimate goal of realizing silicon single-electron spin quantum bits as building blocks for future solid-state quantum computers. In NE we use Si quantum dots defined by electrostatic gating of an electron gas at the Si/SiO_2 interface. The design with three layers of gates allows control of all quantum dot components: the quantum dots themselves, the tunnel barriers and the densities of states in the reservoirs.

In collaboration with the group of Prof. Dzurak at the University of New South Wales in Sydney, we are further developing the Si quantum dots technology towards few-electron double quantum dot devices. The goal is to observe Pauli spin blockade in few-electron Si double quantum dots. Spin blockade can be used to detect single-electron spin resonance, a basic requirement for quantum information processing with single electron spins.

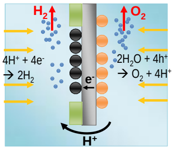
Acousto-electronics

In acoustoelectronics, acoustic waves are utilized to manipulate and transport charge carriers. Particularly interesting are surface acoustic waves (SAWs) in which virtually all acoustic energy is confined within one wavelength of the surface. SAWs typically have a propagation velocity of a few km/s, wave amplitudes of ~1 nm, and the wavelengths range from submicron to ~100 microns. SAWs can be generated and detected by interdigital transducers (IDTs) on a piezoelectric substrate.





Water splitting on a chip

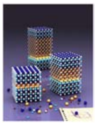


EU patent P91784EP00

With the so-called "Z-scheme" it is possible to split water in hydrogen and oxygen using the visible part of the light spectrum. The process uses different catalysts for the two half reactions to split water in hydrogen and oxygen. By the use of a structured metallic divider the goal is to decrease the recombination of electron-hole pares and to increase the efficiency of the process.

in collaboration with PCS group

Oxide electronics



Complex oxide heterostructures featuring a significant degree of electronic polarization at the interfaces form exciting systems for the creation of novel 2-dimensional electronic and magnetic phases.

We elaborate new techniques for patterning such heterostructures, based on interfaces between **$SrTiO_3$ (STO) and $LaAlO_3$ (LAO)**, with the goal to realize (magneto)electronic charge transport devices.

in collaboration with ICE and IMS groups

Would you like to do your BSc or MSc project in NE?

During your BSc or MSc project you can choose one of the research themes above. You will get the responsibility for your own project, and are supposed to be a full member of the team under supervision of a PhD student or a post-doc. Would you like to get an idea of every-day life in NE? Please look at the other poster on the website, www.nano-electronics.nl.

If you are interested to do a project in NE, then have a look at our webpage for more detailed descriptions of the research directions and up-to-date projects. Often it is difficult to choose based on these short descriptions. We therefore invite you to make an appointment with Prof Wilfred van der Wiel (W.G.vanderWiel@utwente.nl, room CR1441).

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NanoElectronics (University of Twente)

NE Themaposter 2012