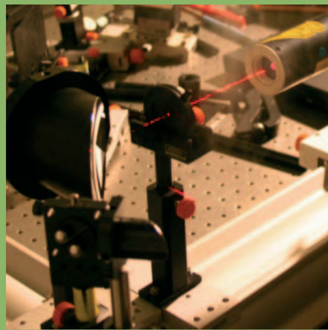
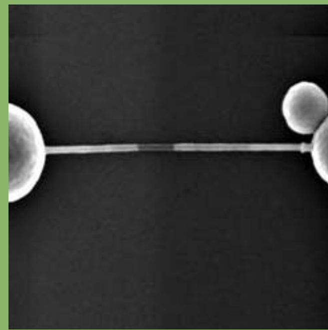




namlab


Materials research for future electronics

Combining industrial and academic expertise


NaMLab (Nano-electronic Materials Laboratory)

The research at NaMLab focuses on materials for electronic devices and new device concepts. Among these are high-k materials for capacitors, transistors and other applications, novel switching devices including memristors, nanowire based electronics as well as materials for energy harvesting devices such as solar cells.

Future nano-electronic products require the development of new materials that are not currently available. NaMLab consequently focuses its research activities on materials and applications that show the potential to offer significant advantages over materials and products used today. In addition to investigating and characterizing new materials, NaMLab is undertaking research on the integration of these materials into semiconductor products with nano-scale dimensions.

NaMLab, originally founded as a research joint venture between Qimonda AG and the TU Dresden in July 2006, has its roots in the Corporate Research Department of Infineon AG and is now owned completely by the Technical University of Dresden. NaMLab receives basic financing from the Saxon Ministry of Science and Arts (SMWK).

The company benefits from excellent working conditions in its office and clean room building opened in October 2007 and located within the TU Dresden campus.

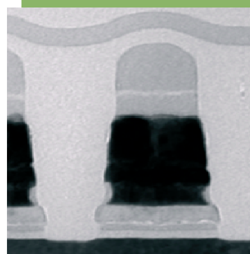
Dresden, September 2010

Prof. Dr.-Ing. Thomas Mikolajick

NaMLab gGmbH is a research organization and associated institute of the Technical University Dresden.

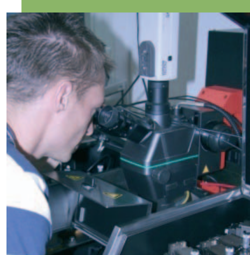
Research Scope
NaMLab provides industry oriented and basic research in materials science for electronic devices. It concentrates on new and promising nano-electronic materials for tomorrow's semiconductor and energy applications.

Research Approach
NaMLab has an industry experienced staff. It combines basic research with methodologies that are proven in the semiconductor industry. Working out a clear view of the target application and its specification is an integral part of NaMLab's materials research.



Co-operations
NaMLab has an extensive cooperation network with leading research organizations enabling research activities from basic material properties to device integration beyond its own experimental capabilities. In particular it has a very close cooperation with the Institute of Semiconductor and Microsystems Technology (IHM) of the TU Dresden.

Clean Room Facilities
NaMLab's facilities conform to the highest standards with 250m² of class 100 (ISO 5) clean room as well as 50m² of class 10 (ISO 4) clean room available for experimentation.
Deposition capability includes sputtering and vacuum evaporation (PVD), molecular beam epitaxy (MBE) and chemical vapor deposition (CVD). A laser cutter with ability to cut any size and shape from wafers up to 300mm allows us to accommodate any customer requirements. NaMLab has developed the ability to manufacture nanowire transistors and together with the TU-Dresden/IHM it maintains a MOS capacitor line.



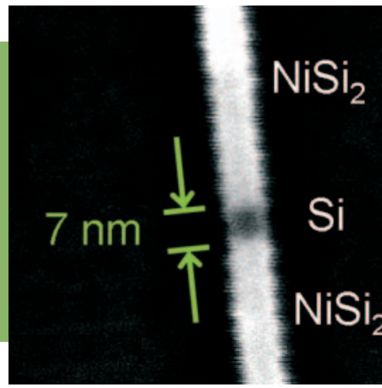
Characterization Facilities
NaMLab also operates a state of the art electrical characterization lab for material and device studies equipped with 200mm and 300mm probe stations. These enable the in depth investigation of electronic device reliability and dielectric behavior including the development of new and customized characterization methodologies.

NaMLab Team

Applications:

Nanowire Based Devices

NaMLab is currently concentrating on the synthesis and integration of nanowires for new electronic applications. These include novel transistors, bio-sensors and reconfigurable circuits. The constantly shrinking dimensions of electronic devices and steadily growing performance targets make alternative materials and device approaches essential. In particular, nanowires made with "bottom-up" methods are considered as potential candidates for future electronic applications. One of our specialties is the production of longitudinal metal-semiconductor-metal hetero structures with atomically abrupt interfaces. They are the heart of the electronic devices & circuits investigated at NaMLab.



The electronic transport mechanisms of these hetero-junctions are studied and modeled to gain the required insight and to exploit their properties for building *Beyond-Moore* electronic devices & circuits:

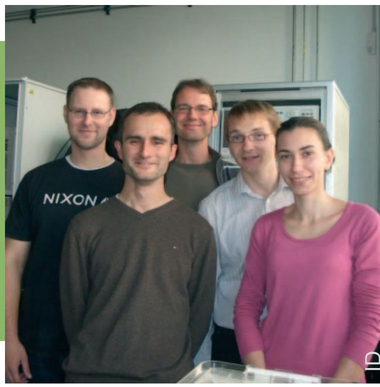
- Reprogrammable transistors in which the polarity can be dynamically switched from p-type to n-type by the application of external signals.
- Reconfigurable circuits that provide extended functionality.
- Highly sensitive bio-sensors, studied in a joint project with the Institute for Materials Science of the TU Dresden (Prof. Dr. G. Cuniberti).

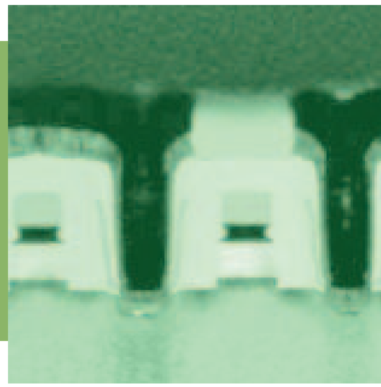
Contact: Walter M. Weber

Applications:

Microelectronic Devices

A key competence of the NaMLab team is the electrical characterization of microelectronic devices for various applications. High performance transistors are investigated with respect to their performance and basic device properties such as mobility and transfer characteristics. Capacitors are evaluated for different applications in the semiconductor industry. In addition, ferroelectric devices, including capacitors and transistors, are studied to determine their memory characteristics and parameters such as polarization, reliability, retention, imprint and fatigue.





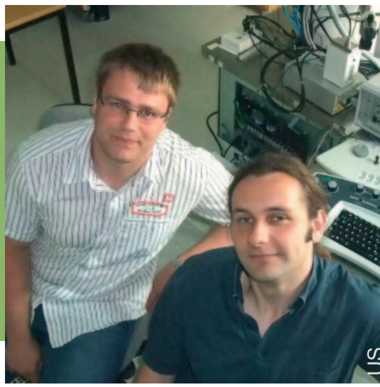
In depth methods are available to characterize the oxide charges, positions and densities as well as capacitance and leakage mechanisms. State-of-the-art methods incorporating high-k bias temperature stress, fast time dependent break-down, dielectric relaxation and stress induced leakage current have been established to analyze the reliability of devices. The results are employed to predict the device lifetimes.

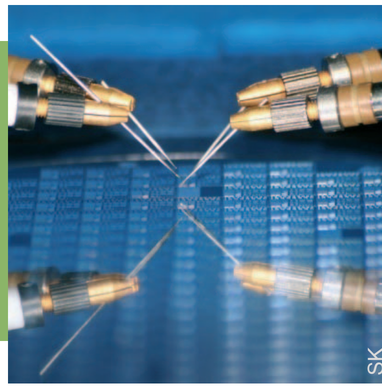
Electrical characterization of microelectronic devices is also possible at very low temperatures and over a very broad voltage range enabling investigations for automotive and energy switching applications.

Contact: Microelectronic Devices: Stefan Jakschik
Ferroelectric Devices: Uwe Schroeder

Applications: **Memristor**

The memristor was proposed in 1971 by Prof. Leon Chua as the fourth passive circuit element alongside the well known resistor, inductor and capacitor. The memristor is a two terminal device with a behavior similar to that of an ohmic resistor. However, the value of the resistance depends on the current or the electrical flux history of the device. If no voltage is applied or no current flows, the actual resistance is conserved. Thus, it is a resistor with memory. Its unique behavior, which can't be emulated by any combination of the other three passive circuit elements, makes the memristor interesting for many emerging applications, such as memory devices, switches in reconfigurable electronics or synaptic connections in artificial neural networks.





In the BMBF project (Multifunktionale Speicher), we focus on the electrical characterization and comparison of different resistive memory types which are developed together with our project partners. The concepts include spin transfer torque memory (FZ Dresden) and resistive switching in organic materials (IAPP TU Dresden). Another candidate is the ion migration based resistive switching in metal oxides which is explored within a DFG project (HANSEL).

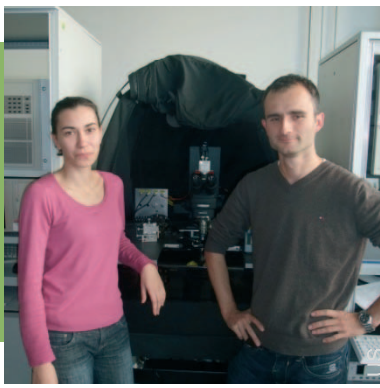
The memristor is a highly promising candidate for the realization of dense synaptic connections in artificial neural networks due to its attractive possibilities for nano-scale integration.

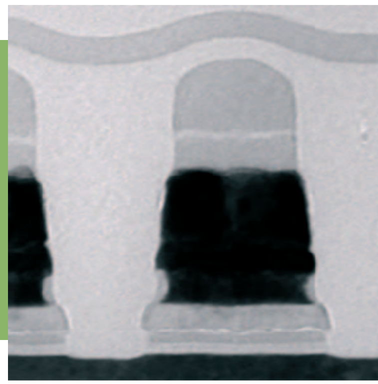
Contact: Stefan Slesazeck

Applications:

Charge Trapping Memory

One of the fields of research at NaMLab is the analysis of structures for non-volatile semiconductor memories. The EU project “Gossamer,” running within the EU FP7 framework, investigates memory devices with trap-based memory layers for the next generations. This technology is the most promising candidate to replace today’s dominant floating gate structures in NAND flash memory devices.
The research activities concentrate, on the one hand, on the modeling of the electrical characteristics of memory cells and, on the other hand, on the





electrical characterization of single cells. In order to meet the project’s overall goal it is necessary to integrate new materials into the layer stacks of the memory cells. Aluminum oxide, which shows higher relative dielectric constant, is used instead of SiO_2 as a possible blocking dielectric. Furthermore, it will be evaluated whether the introduction of metal gate electrodes has a positive effect on the electrical characteristics.
NaMLab is developing physical models which describe the working principals of charge trapping memory cells. The memory cell relevant reliability parameters, such as the energy distribution of the traps, are under investigation in addition to the effect the materials have on the reliability.

Contact: Thomas Melde

Applications:

Energy Harvesting

Thin film nano-materials play a major role in future energy harvesting technologies. We have different approaches to this research utilizing the experience of the Namlab team with the charging behavior of thin dielectric layers in silicon technology. Thin dielectric layers and the influence of doping and crystallinity on the passivation behavior of silicon solar cells are being investigated in detail. Here the focus is on materials such as Al_2O_3 with different dopants. In addition, semiconductor nano-crystals and the energy transfer to rare earth elements is being studied.

The films are deposited by thin film deposition methods. Very precise size control of the nano-crystals can be introduced utilizing a so-called superlattice approach. The energy transfer to the rare earth elements enhances light emission and up-conversion properties: Light can be transformed from infrared into the visible wave lengths.
In dye-sensitized-cells thin TiO_2 layers on nano-crystalline TiO_2 deposited by ALD are used to stabilize a certain crystalline phase of TiO_2 and enhance the electron transfer from the dye to the nano-crystalline TiO_2. Furthermore, Si-nanowires are being investigated as anode material for future lithium ion battery applications. These electrodes allow up to a ten-fold increase of the charge density.

Contact: Stefan Jakschik