Abstract of the PhD Thesis:

Carbon nanotube based networks,bio-nano-compositesand sensors.

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The formation of a photosensitive device due to the local breakdown in an MOS structure with an impurity containing oxide layer has been observed. A stepwise breakdown of the oxide layer resulted in the formation of a transistor like characteristics with further on stable current-voltage characteristics. A high value of the photosensitivity of the resulting structure has been found, when illuminated with white or blue light. This can be explained by the formation of a local p-n junction during electrical breakdown due to out-diffusion of dopants from the oxide into the underlying silicon substrate. The development of the photocurrent has been monitored during breakdown formation. This monitoring procedure can be used for the optimization of the photosensitive device. After these experiments a defect-free oxide was produced and tested. Multi walled carbon nanotubes (MWCNTs) have been deposited by casting electrophoresis on top of this SiO_2 layer.

Using three different microscopy techniques: namely Atomic Force Microscopy, Secondary Electron Microscopy and Focused Ion Beam Microscopy, the geometry of the interconnection of a single junction between the deposited MWCNTs has been investigated in detail. A very particular twisted interconnection geometry has been observed. Furthermore a strong stability of the sample in time has been observed proving a strong adhesion of the tubes to the SiO_2 surface.

Furthermore, MWCNTs were deposited from two different solutions leading to different results regarding their morphology: an almost bi-dimensional "carpet" of MWCNTs, and a network composed of a very limited number of MWCNTs. The "carpet" was obtained using a solution with 1% of sodium dodecyl sulfate in de-ionized water, saturated with MWCNTs. This solution was very stable in time and reproducible carbon nanotube networks could be obtained. All the pure nanotube networks were deposited by di-electrophoresis inside an aluminium contact gap with a contact

distance of 3μm. After the deposition the temperature dependent conductivity of the MWCNTs "carpet" inside the aluminum contact gap has been determined. The temperature behavior of the conductivity shows a good qualitative agreement with the fluctuation induced tunneling model for disordered materials. A rapid reduction of the random telegraph noise present in the virgin devices has been observed after relatively short application of a constant voltage. This increases the possibilities to use aluminum contacts for electronic CNT devices like sensors, where device stability is more important than high current levels. When a different solvent has been used, that resulted in a much lower concentration of CNTs within the micro-gap, a stable electrical behavior has not been achieved.

Successively using the same technique for the solution of MWCNTs a *Candida albicans*/multi walled carbon nanotube (Ca/MWCNTs) composite material has been produced. It can be used as a temperature-sensing element operative in a wide temperature range (up to 180 °C). The Ca/MWCNTs composite has excellent linear current-voltage characteristics when combined with coplanar gold electrodes. Growing cells of *C. albicans* were used to structure the carbon nanotube-based composite. The fungus *C. albicans* combined with MWCNTs co-precipitated as an aggregate of cells and nanotubes that formed a viscous material. Microscopic analyses showed that Ca/MWCNTs formed an artificial tissue. Slow temperature cycling was performed for up to 12 days showing a stabilization of the temperature response of the material. As another application of this new bio-nano-composite layer, the realization of a flexible transparent conductive film has been demonstrated.

A more general procedure in order to obtain novel artificial materials has been proposed and realized using isolated tobacco cells in combination with carbon nanotubes. The electrical, mechanical, optical, thermo-electrical properties of these materials have been determined. Using tobacco cells, a material with low mass density and mechanical properties suitable for structural applications, along with high values of the electrical conductivity has been obtained. Measurements of the mechanical and electrical behavior have been combined with theoretical modeling. These findings indicate a procedure for next generation cyborg nano-composite materials.