

Schottky Behavior of Metal / n-Si(111) Nanodiodes

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Quantum effects become observable at room temperature if the structure width decreases to atomic dimensions [1-3]. Gimzewski and Möller found quantized conductance in atomic point contacts [4]. So far, the basic electronic device, a metal / semiconductor diode, was only less investigated in atomic point contact dimensions [5,6]. Electrochemically grown nanodiodes have not been investigated in the literature.

Using the Scanning Tunneling Microscope (STM) in an electrochemical environment, our solely electrochemical process of localized electrodeposition, allows us to deposit low dimensional metal clusters onto semiconducting substrate surfaces at predefined substrate positions [7-9]. In that way we are able to grow 2D nanodiodes with well defined contact areas in the range of several 10 nm².

Phosphorus doped n-Si(111) was cleaned after the well known RCA method [10]. Subsequently, an etching procedure with HF and NH₄F was applied resulting in well defined atomically flat, hydrogen terminated surfaces [11]. The electrolytes have been prepared from suprapure chemicals. In dependence of the deposited metal deaerated sulfuric or perchloric support electrolytes have been used with a concentration of 20 mM. All measurements were taken *in-situ* and "in the dark" to avoid oxidation and degradation of the silicon surface.

We present *in-situ* current / voltage characteristics of electrochemically grown metal / n-Si(111) bulk and nanocontacts. According the relation between the Fermi energy levels of the deposited metal and the silicon we have chosen one metal with a Fermi energy level above the silicon Fermi energy level, Pb, and two metals with Fermi energy levels below the silicon Fermi energy level, Cu and Au.

From measurements across bulk contacts in the systems Cu / Si(111) and Au / n-Si(111) we obtained perfect Schottky behavior, whereas at electrochemically grown Pb / n-Si(111) interfaces ohmic behavior with resistances of few ohms is obtained.

In-situ voltage spectroscopy on nanocontacts has been carried out utilizing the STM. With the high precision of our STM setup we were able to contact the metal part of the nanodiode via the STM-tip. We eliminate the contribution of the Faraday current by measuring the current on the electrode which has not been ramped.

Besides the low thermal drift in our STM setup, this allows us additionally to reduce the influence of the thermal drift by decreasing the measuring time due to bias voltage sweeps with up to 100 V/s.

First interpretations of the obtained characteristics have been done using the thermionic emissions model.

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