Metal – Silicon Interfaces:
Electrodeposition and *in-situ* Characterization

Werner Schindler [1,*)], Martin Hugelmann [2)], Philipp Hugelmann [2)]

[1)] Abteilung Elektrochemie, Universität Ulm
DE-89069 Ulm (Germany)
[2)] Institut für Hochfrequenztechnik und Quantenelektronik
Universität Karlsruhe (TH)
Kaiserstrasse 12, DE-76131 Karlsruhe (Germany)

Silicon substrates may play an important role for nano-device fabrication since they can be prepared in a remarkable surface quality at simultaneously low cost. Magnetic and metal nanostructures prepared on silicon substrates should show a much more pronounced electron confinement than comparable structures on metal substrates. Novel applications may utilize these quantum size effects of nanometer sized nanostructures deposited onto silicon substrates.

Despite the importance of metal nanostructures deposited onto silicon surfaces only a few scanning probe microscope investigations of the initial stages of metal deposition onto silicon surfaces have been reported [1-4]. *In-situ* investigations of the properties of electrochemically deposited metal structures on silicon substrates are rarely found in the literature.

Here, we present *in-situ* STM investigations of metal deposition onto n – Si (111) : H surfaces from aqueous solutions combined with *in-situ* cyclic voltammetry. *In-situ* current / voltage measurements have been carried out to investigate the electronic properties of the grown metal / n – Si (111) : H interfaces.

Defined potential pulses at n – Si (111) : H surfaces result in uniform size distributions of Co - , Cu - , and Au - clusters. These metal clusters are very stable under STM conditions, whereas Pb - clusters seem to be less stable under comparable STM conditions. The electrochemical deposition of Co, Cu, and Au is strongly irreversible with clear deposition but less pronounced dissolution peaks. In contrast, in the case of Pb / n – Si (111) : H clear deposition and dissolution peaks are found. The electrodeposition of metals is determined by the Nernstian 3D equilibrium potential and the flatband potential of the silicon substrates, as well as by the chemistry of the interface formed between metal deposit and silicon substrate surface.

In-situ spectroscopic measurements across laterally extended, as well as across nanostructured metal / silicon contacts have been carried out to clarify the electronic behavior of these contacts. In the case of Co / n – Si (111), Cu / n – Si (111), and Au / n – Si (111) an excellent rectifying behavior is found. Electrochemically grown Pb / n – Si (111) : H contacts show an ohmic behavior. The extracted Schottky barrier heights and ideality factors are in very good agreement with values found for contacts fabricated with conventional ultra high vacuum methods.

References:

1. J. Z. Ziegler, G. E. Engelmann, and D. M. Kolb, Z. Phys. Chem. **208**, 151 (1999).
2. R. T. Pötzschke, G. Staikov, W. J. Lorenz, W. Wiesbeck, J. Electrochem. Soc. **146**, 141 (1999).
3. T. Zambelli, M. L. Munford, F. Pillier, M.-C. Bernard, and P. Allongue, J. Electrochem. Soc. **148**, C614-C619 (2001).
4. W. Schindler, P. Hugelmann, M. Hugelmann, F.X. Kärtner, J. Electroanal. Chem. **522**, 49 (2002).

[*)] e-mail: werner.schindler@gmx.de