Electrodeposition of Nanoscale Germanium and Silicon in Room Temperature Ionic Liquids - F. Endres (Technical University of Clausthal)

Ionic liquids are molten salts that have, by definition, a melting point below 100 ^{o}C. Many of these systems are liquid at room temperature and thus they are well suited for the investigation of the processes during electrodeposition of metals or semiconductors on the nanoscale, e.g. with the in situ STM. Among the many liquids that are known today, 1-Butyl-3-methylimidazolium hexafluorophosphate and 1-Butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide are interesting candidates for electrochemistry because of extraordinary physical properties: they have a high chemical stability and low vapor pressures even at elevated temperatures, they can easily be dried under vacuum to water contents below 1 ppm and they have on Au(111) electrochemical windows of 4 and 5 Volts, respectively. The first liquid is well suited for the electrodeposition of germanium, whereas only the second liquid has a sufficiently wide electrochemical window for the electrodeposition of silicon. The germanium deposition on Au(111) starts with underpotential deposition at step edges followed by island growth on the gold terraces. Before the OPD sets in the islands close to an around 300 pm thick rough germanium layer with metallic properties. In the OPD regime a cluster growth sets in and it is possible to deposit clusters with a narrow height distribution, the clusters have heights between 1 and 10 nm. Interestingly with rising thickness apparently a metal to semiconductor transition is observed, whereas layers of more than 20 nm show reproducibly the expected band gap of 0.7 eV at room temperature. From the second liquid silicon can be electrodeposited in elemental form. Layers of 100 nm thickness seem to consist of small crystallites. In situ current/voltage tunneling spectroscopy of 100 nm thick silicon layers reveals the expected band gap of 1.1 eV. The importance of ionic liquids for (nanoscale) electrochemistry will be pointed out.