UHV-EC Studies of the Surface Chemistry of InP(100) wafers, as Substrates for the Electrodeposition of Compound Semiconductors

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The focus of your group has been Electrochemical Atomic Layer Epitaxy (EC-ALE) for many years. EC-ALE is the electrochemical analog of Atomic Layer Epitaxy (ALE) or Atomic Layer Deposition (ALD), methods for forming compounds an atomic layer at a time using surface limited reactions. The principle is the alternate the deposition of atomic layer of the elements making up a compound, and thus growth the compound in the layer by layer growth mode. Surface limited reactions in electrochemistry are generally referred to as underpotential deposition (UPD) [1-4], and thus EC-ALE is the use of UPD to do ALE.

Most of the work on EC-ALE performed by this group has been on Au substrates, although some work has been done using Cu, and ITO [5]. Foresti et al. [6-8] have focused on Ag substrates for their studies of EC-ALE.

As the compound formed using EC-ALE are II-VI, IV-VI, and III-V compounds, all of interest for optoelectronics, it would be advantageous to develop methodologies to deposit on standard semiconductor substrates. Electrodeposition on Si has been shown to follow a nucleation and growth mode, nearly universally. Some work has been performed by this group to understand the surface chemistry of GaAs and InP as substrates for electrodeposition. These are the two most widely used compound semiconductor substrates used in industry, and thus available at a reasonable price.

The problem is that there is a vast difference between an elemental substrate like Au, and a compound. First, the electrochemistry of Au is well studied and understood. On the other hand, the electrochemistry of a compound involves stoichiometry. That is, when a compound surface is prepared, say InP, there are questions such as is the surface In or P? Or is the surface some mixture? In the case of Au, as long as no other elements are present, you are fairly sure the surface is Au.

InP has been used successfully as a substrate for the electrodeposition of compounds. However, most of that work has involved the use of codeposition [9-12]. In the case of EC-ALE, the more that is known about the structure of the substrate surface, the better the chances of depositing good quality materials.

This talk will involve descriptions of the preparation of InP(100) substrates subsequent studies of UPD and EC-ALE of compounds.

A cleaning method has been developed starting with the a commercial wafer. Wet etches are first used, as well as UV-ozone cleaning. After transfer to the UHV surface analysis instrument, Ion-bombardment, followed by annealing are used to produce what we call a “clean” surface: one that shows no elements besides In and P in the Auger electron spectra, and a (2X4) LEED patter. However, when this clean substrate is transferred to solution at -0.7 V, vs. Ag/AgCl, there is a significant oxidation peak between -0.7 and -0.6V during the positive going scan. It has been concluded that this peak is the oxidation of elemental In. Once this oxidation has been performed, there are no more oxidation features until 0.1V, where the substrate starts to oxidize, both In and P.

The electrodeposition of In, Sb, Cd, and Te have all been studied, as well as possible routs to the formation of InSb, and CdTe using the EC-ALE method.

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