

Electrodeposition of Au Thin Films and Au/Ag Multilayers on Silicon

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INTRODUCTION

The deposition of noble metal thin films onto metallic and semiconductor substrates is important in many modern technologies. Here we report on the electrochemical deposition of gold thin films and gold/silver multilayers. We show that high quality thin films and multilayers can be deposited from cyanide-based solution.

RESULTS AND DISCUSSION

All experiments were performed on n-type Si(100) (Wacker Siltronic, AG) with a resistivity of $3\Omega\text{ cm}$ ($N_D = 1 \times 10^{15}\text{ cm}^{-3}$). Prior to each experiment the wafers were sequentially cleaned ultrasonically for 10min in acetone, ethanol, and water. The ohmic contact was formed on the backside of the wafer by applying InGa eutectic after treatment in 48% HF for 10s. The electrochemical experiments were performed in a three-electrode cell under ambient conditions. All potentials are reported with respect to the Ag/AgCl (3M NaCl) reference (0.195V vs. SHE). Nucleation and growth transients were recorded by switching the potential from open circuit potential, where no deposition occurs, to a potential in the deposition regime. In all case, the induction time was subtracted before analysis.

Fig.1 shows the current-potential curves for n-Si(100) in 1M KCN + 1M KOH (pH 14) with and without 50mM $\text{KAu}(\text{CN})_2$. In the absence of $\text{KAu}(\text{CN})_2$, a large reduction current is observed at potential more negative than about -1.9V due to hydrogen evolution. In the $\text{KAu}(\text{CN})_2$ solution, gold deposition is observed with an onset at about -1.25V in the first scan, and a current peak is observed at -1.30V with a maximum of 7.2mAcm^{-2} . The current peak indicates that, after nucleation, gold deposition becomes diffusion limited. At about -1.60V the current increases again due to hydrogen evolution. The current onset for hydrogen evolution is shifted by about 0.3V with respect to the scan for the solution without gold cyanide ions since the reaction is catalyzed at the deposited gold. On the reverse scans no stripping current is observed, indicating that gold deposition on n-type silicon is not reversible. The onset of gold deposition after the first scan is about 0.2V more positive than in the first scan indicating that there is an energy barrier for gold nucleation.

Fig. 2 shows a series of current transients for the deposition of gold from 2mM $\text{KAu}(\text{CN})_2$ + 0.2M KCN (pH 14) solution. The transients are qualitatively consistent with the models for nucleation of 3D clusters and diffusion limited growth.

Fig. 3 shows an AES depth profile of the Au/Si junction deposited from 50mM $\text{KAu}(\text{CN})_2$ + 1M KCN (pH 14), illustrating a sharp interface. Oxygen was not detected either in the film or at the interface.

FIGURES

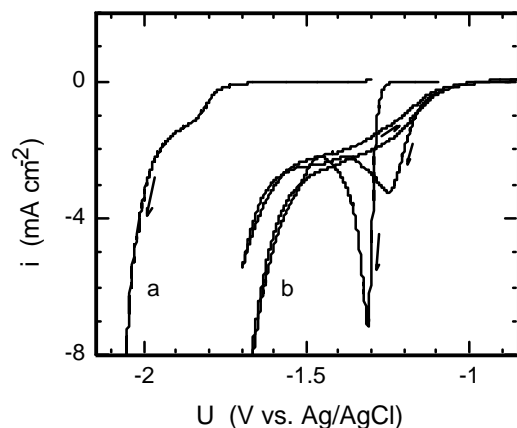


Fig. 1: Current - potential curves for n-Si in 1M KCN solution at pH 14 (a) without and (b) with 50mM $\text{KAu}(\text{CN})_2$. The solid line corresponds to the first scan which was started at -0.85V, and the dotted line shows the third scan which represents the final shape of the voltammogram. The scan rate was 10mV s^{-1} in all cases. The arrows indicate the scan directions.

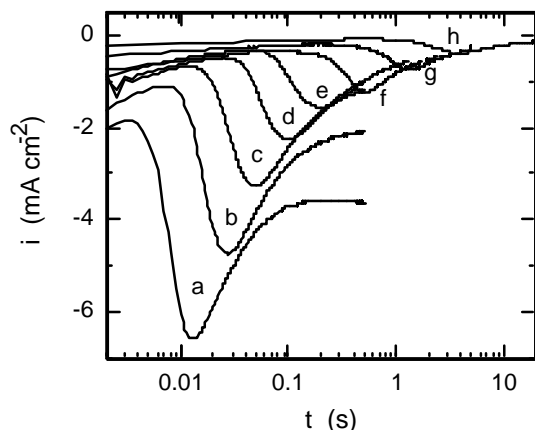


Fig. 2: Current transients in 2mM $\text{KAu}(\text{CN})_2$ with 0.2M KCN at pH 14 for potential steps from the open circuit potential to: (a) -1.65V, (b) -1.60V, (c) -1.55V, (d) -1.50V, (e) -1.45V, (f) -1.40V, (g) -1.35V and (h) -1.29V. Note that the time axis is shown in a logarithmic fashion.

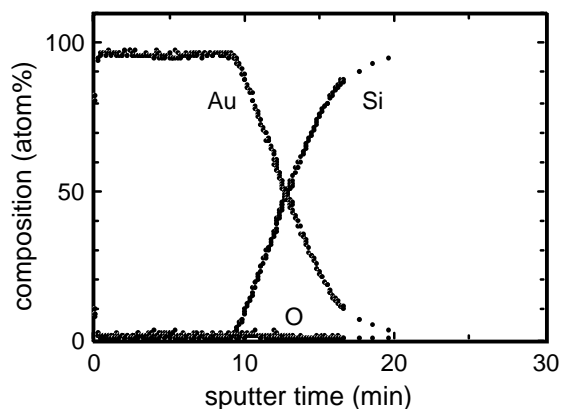


Fig. 3: Auger electron spectroscopy depth profile for a Au/n-Si junction. The gold film was deposited from 50mM $\text{KAu}(\text{CN})_2$ + 1M KCN (pH 14).