AFM induced nanoscale electrochemical deposition of metals on Si (100) surfaces

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Electrochemical deposition of metals and alloys onto metallic substrates plays an important role in many modern technologies. In the electronics industry, electrochemical and electroless deposition are widely used for applications, such as copper printed circuit boards, through-hole plating, multilayer read/write heads, and thin film magnetic recording media [1]. Surprisingly, there have been relatively few reports on the electroless, or electrochemical, deposition of metals onto semiconductors despite the technological importance of metal/semiconductor contacts for Schottky junctions and metallization.

Scanning probe microscopy (SPM) such as atomic force microscopy (AFM) and scanning tunneling microscopy (STM) have been widely used as tools for surface imaging with atomic resolution. But AFM can also be used to nanomachine the surfaces in the micro- and nanoscale, e.g. in scratching and wear [2]. It has been demonstrated that it is possible to obtain nano-scratches on silicon surface using an AFM equipped with a monocrystalline diamond tip [3]. Other works have investigated the in-situ modification of the surfaces by electrochemical-atomic force microscopy (EC-AFM) [4].

This work explores the possibilities to use AFM-scratching as pre-sensibilization for selective metal (Au, Cu and Pd) electrochemical deposition on *p*- and *n*-type Si

The principle of the selectivity has been demonstrated before [5, 6]. It is based on the modification of the semiconductor/electrolyte interface behavior intentionally and controlled defect creation.

The first step of the work was to produce and study the AFM-scratches on the silicon substrate (Fig. 1). In the second step, the metal electrochemical deposition onto silicon surfaces was carried out by applying a cathodic potential step in metal ion containing electrolyte.

Electrochemical parameters of the metal deposition were studied in this work. The metallic lines were characterized by different microscopies (AFM and scanning electron microscopy) and Auger electron spectroscopy. Under optimized conditions total selectivity for the scratched locations can be achieved for Au, Cu and Pd deposition (see e.g. selective Cu deposit in Fig. 2).

References

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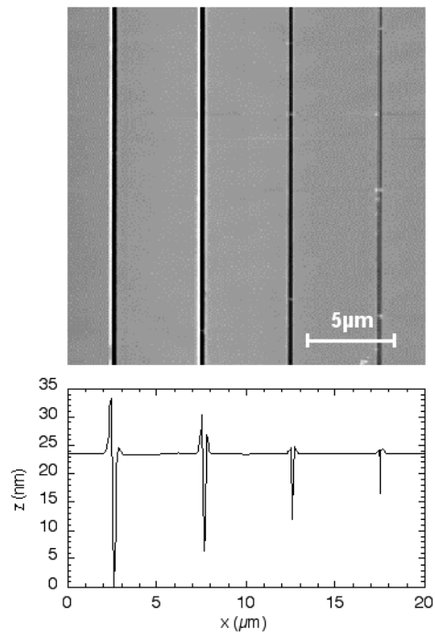

Fig. 1: AFM top view and profile of 4 AFM-scratches produced with different normal loads (14, 17, 20, 23 µN).

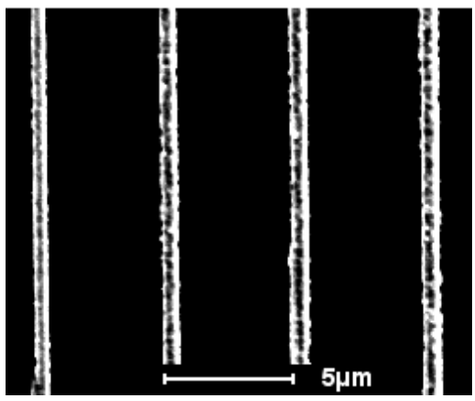

Fig. 2: SEM image of copper deposit produced on AFM-scratched silicon surface. The grooves were imprinted with a force of 15 µN.Deposition was carried out from $CuSO_4$ (0.01 M) + H_2SO_4 (0.05 M) at -400 mV (Ag/AgCl) during 15 s.

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