

Selective Pd electrochemical deposition on Si (100) surfaces assisted by AFM

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Palladium is used in a number of industrial applications and fundamental studies because of its high catalytic activities for many chemical reactions (e.g. ability to adsorb hydrogen) [1]. During the past decades, a great deal of interest for Pd has emerged in the semiconductor field. Pd electrodeposition technology is often used in electronic industry replacing gold and platinum as a contact material for interconnection [2]. Pd films deposited on semiconductor surfaces can also be used for electronic devices like Schottky diodes or solar cells [3, 4].

Patterned metal deposition on semiconductor surfaces is typically carried out by different masking approaches such as photolithography combined with metal evaporation, electrodeposition or molecular beam epitaxy.

Recently, direct nanoscale in-situ modification of surfaces by scanning tunneling microscopy (STM) attracted a great deal of interest. The process involves metal deposition from the solution onto the tip and subsequent transfer of metal from the tip to the substrate [5]. Using this method, it was possible to obtain tip-induced nanoscale electrochemical deposition of palladium on an Au(111) electrode [6].

More recently, it has been demonstrated that it is possible to obtain nano-scratches on silicon surface using an atomic force microscopy (AFM) equipped with a single-crystalline diamond tip [7]. Using this scratching method with a diamond coated tip as surface pre-sensitization, selective copper deposition onto silicon was performed in the sub-micrometer range [8].

This work explores the possibilities to use AFM-scratching as pre-sensibilization for direct and selective Pd electrochemical deposition on *p*- and *n*-type Si.

The principle of the selectivity has been discussed before [8-10]. It is based on the modification of the semiconductor/electrolyte interface behavior in the scratched region combined with a masking effect of the native oxide layer present on the silicon surface. The first step of the work is to realized the AFM-scratches on the silicon substrate (Fig. 1). The groves are 40 μm long, 100 nm wide and 10 nm deep. In the second step, the palladium electrodeposition onto silicon surfaces was carried out by applying a cathodic potential step in a PdCl_2 (0.01M) and HCl (0.1M) electrolyte.

Parameters like duration and voltage of the potential step were studied in this work. The palladium lines were characterized by different microscopies (AFM and scanning electron microscopy) and Auger electron spectroscopy. Under optimized conditions total selectivity of the deposition can be achieved as shown in figure 2.

The work therefore demonstrates that this new technique can be applied to direct nanoscale Pd patterning on semiconductor surfaces.

References

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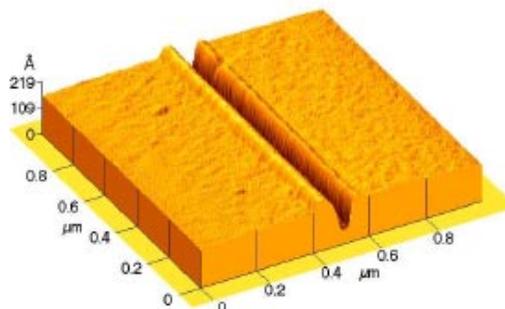


Fig. 1: AFM 3D-view of an AFM-scratch in *p*-type Si (100) realized with a normal load of 14 μN

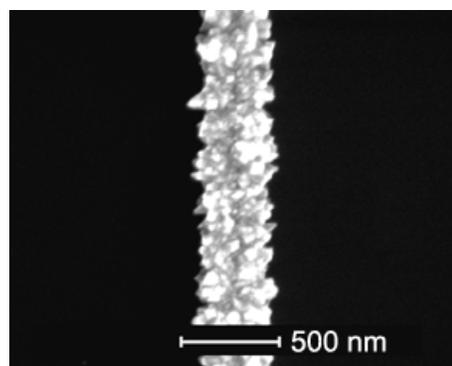


Fig. 2: SEM image of a AFM-scratched *n*-type silicon surface after direct palladium deposition. Pd deposition was carried out in PdCl_2 (0.01M) + HCl (0.1M) at +50 mV (Ag/AgCl) during 30 s.

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