Influence of an external magnetic field on the structure of electroplated ferromagnetic layers based on nickel

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The enhancement of mass transport by an external magnetic field in electrochemical reactions has been shown by several research groups. The main reasons for this effect are Lorentz forces that induce a forced convection (magnetohydrodynamic effect) [1-3]. In the case that the deposited layer is ferromagnetic, additional magnetic dipolar forces will also be induced. However, the question if a moderate magnetic field (up to 1 T) influences the structure and the morphology of an electroplated layer and the underlying mechanisms of nucleation and growth are still not fully understood. The topic is discussed controversially in literature.

This paper will present recent results on thin ferromagnetic layers (nickel and nickel alloys) which were electroplated in static magnetic fields up to 1 T. Electrochemical Quartz Crystal Microbalance (EQCM) was used to characterize the mass balance of the deposition process in situ. From the ratio of the mass and the passed charge the current efficiency of the deposition process could be calculated. It was found that the current efficiency showed a significant dependence on the magnetic flux density B. For small current densities (up to -1 mA/cm^2) the current efficiency of Ni deposition decreased with the magnetic field, whereas an opposite effect was found for higher absolute values of the current density (from -10 to -50 mA/cm^2). These results will be discussed on the basis of the complex interplay of the nickel deposition and hydrogen evolution reaction. AFM (ex situ) was used to characterize the topography of the layers. In the case that the external magnetic field was applied parallel to the surface of the working electrode, an increase in roughness was observed (Fig. 1). In situ information about the surface roughness which could be obtained from the damping of the quartz crystal micro-balance [4] agreed well with the AFM data. Furthermore, the magnetic behavior (investigated with Vibrating Sample Magnetometer) of layers prepared with and without external magnetic field will be discussed.

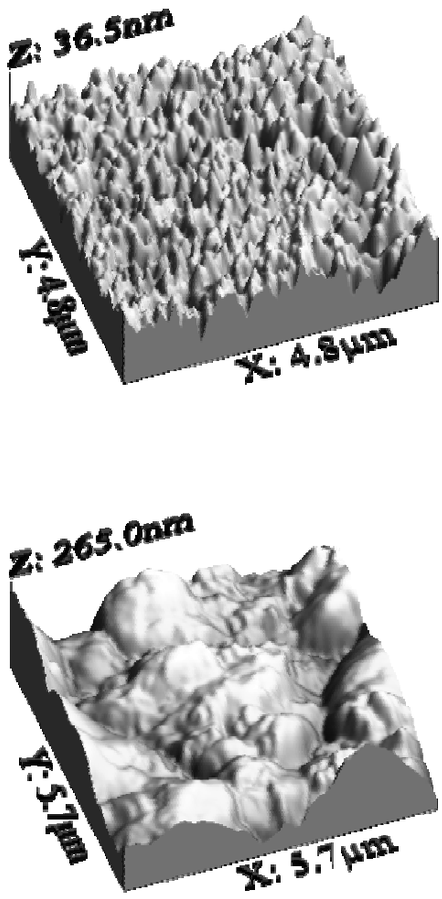

Fig. 1 Surface morphology (AFM) of nickel layers deposited at -50 mA/cm^2 in the absense (top) and in the presence of a magnetic field (0.74 T) parallel to the electrode surface.

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