MODELING OF ELECTROCHEMICAL PATTERN ETCHING: INFLUENCE OF CONVECTION

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Anisotropic chemical etching of a copper foil sandwiched between a photoresist mask and an insoluble support has been studied intensively by Alkire et al. in a series of papers. In one of these papers [1], a mathematical model has been developed which describes the influence of hydrodynamic processes on etch anisotropy. The authors considered the locale velocity and concentration fields inside a two-dimensional rectangular cavity, i. e. at the beginning of the etching procedure, only. Since, later on, this initial unetched assemly developes with time and complex-shaped cavities with completely different local hydrodynamic flow patterns are created, there is a need for a mathematical model considering the temporal evolution of the cavity-geometry, too. In using primary current density distribution (i. e. the kinetic resistance of the interfacial reaction is considered to be negligible compared to the ohmic resistance) such a model has been used by Landolt et al. [2] for electrochemical etching processes. But, because of the assumption of vanishing concentration gradients, the influence of convection and diffusion is not included in this model.

In this contribution, a mathematical model will be presented which allows for a complete description of the influence of convection on the etch anisotropy, since it yields the temporal evolution of the etch profile as well as the velocity and concentration field within the corresponding complex-shaped cavities. Therefore, the model contains the full Navier Stokes equation with a numerical solver for arbitrary cavity-geometries [3]. The study is restricted to electrochemical through foil pattern etching. In order to study the influence of hydrodynamic flow patterns (especially of recirculating eddies) three typical situations during the through foil etching process have been selected: (i) the initial unetched assembly (eddies in the interior corners of the cavity), (ii) a situation *before* the support is exposed to the electrolyte (eddies in the undercut-region), (iii) a situation *after* the support is first exposed to the electrolyte (decomposition of the two dimensional conducting line into a system: conducting line / insulating line / conducting line). Fig. 1 shows the locale ion surface concentration along the conducting line before the support is exposed to the electrolyte (flow enters the reactor from the left hand side). Evidently, because of the pronounced eddies in the undercut-region, the dissolution products acumulate in this region. Such a situation corresponds to a minimum in the current density distribution (see, Fig. 2).

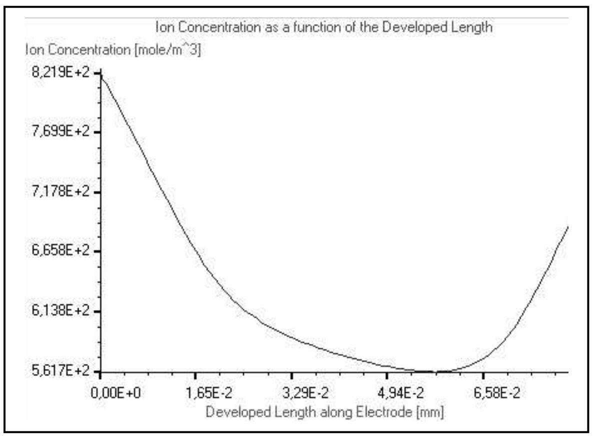

Fig. 1. Typical locale ion surface concentration along the conducting line before the support is exposed to the electrolyte (asymmetric flow conditions)

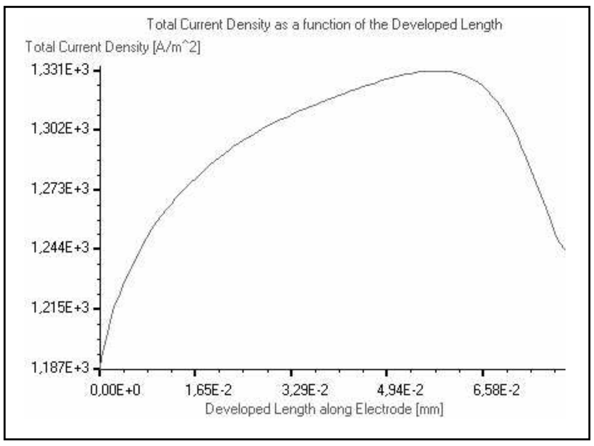

Fig. 2. Typical (tertiary) current density distribution along the conducting line before the support is exposed to the electrolyte (asymmetric flow conditions)

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[1] M. Georgiadou and R. Alkire, J. Electrochem. Soc., Vol. 141, Nr. 3, 1994
[2] A. C. West, C. Madore, M. Matlosz and D. Landolt, J. Electrochem. Soc., Vol. 139, Nr. 2, 1992
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