ON THE MODELING OF ANISOTROPIC ELECTROFORMING- AND MICROMACHINING - PROCESSES

B. Mollay[1,4], B. Van den Bossche[5,6], G. Nelissen[6], J. O. Besenhard[1,2], G. Fafilek[1,3], H. Kronberger[1,3], J. Deconinck[5,6], G. E. Nauer[1,4]

[1]ECHEM Center of Competence in Applied Electrochemistry, Wr. Neustadt, Austria
[2]Institute for Chemical Technology of Inorganic Materials, TU Graz, Austria
[3]Institute of Chemical Technology and Analytics, TU Wien, Austria
[4]Institute of Physical Chemistry, University Vienna, Austria
[5]Vrije Universteit Brussel, Brussels, Belgium
[6]ELSYCA, Brussels, Belgium

Electroforming- and micromachining-processes play an important role in the fabrication of various devices. In order to elaborate suitable operating conditions corresponding to the industrial requirements, modeling turned out to be a very usefull tool in this field. For instance, in the framework of this contribution, some processes for the creation of defined structures will be optimized via modeling to overcome the serious problems caused by the isotropic nature of metal-deposition and metal-dissolution, respectively.

If one tries to produce a defined structure by applying a direct current electroforming process on a photolithographically structured metal surface, pronounced growth over mask effects occur (because of the lateral components of the current density distribution corresponding to the isotropic growth of the deposit). It can be demonstrated by modeling (temporal discretized Potential Model with moving boundary conditions [1]), that such growth over mask effects (side broadening) can be efficiently suppressed by the application of pulse reverse techniques. Within the sequence, the anodic pulse of high current density represents a micromachining step etching away the laterally accumulated material. From Fig.1 one can see, that a properly chosen length of the reverse pulse can force the growth to become anisotropic, thus directing the electroforming process toward the desired deposit profile.

On the other hand, if one tries to produce a defined structure by an electrochemical through foil etching process, the isotropic nature of the dissolution-process causes an undercutting effect. The extend of undercutting is closely connected with the so-called etch factor, which represents a criterion for the quality (desired: a steep flank-angle) of the resulting line. In order to model the etch process, the temporal discretized Potential Model with moving boundary conditions [1] has been used again. Since the machining direction changes when support is first exposed to the electrolyte (decomposition of the two dimensional conducting line into a system: conducting line / insulating line / conducting line), simulations have been performed in two steps. Contrary to the work of Landolt et al. [2], charge transfer resistance is considered (i. e. assumption of a non-zero Wagner number). This fact is of great importance for the optimization of the process with respect to the etch factor, because the flank-angles are dependent on the current density in the case of secondary current density distribution, only. From Fig. 2 one can see, that - for a given undercutting - the angle is more steep (i. e. the etch anisotropy is higher) when working with a higher current density.

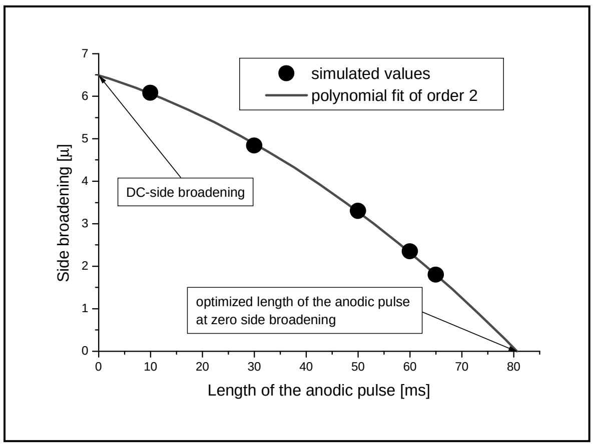

Fig. 1. Optimization of the anodic pulse when using a pulse reverse electroforming process (width of the mask 100µm).

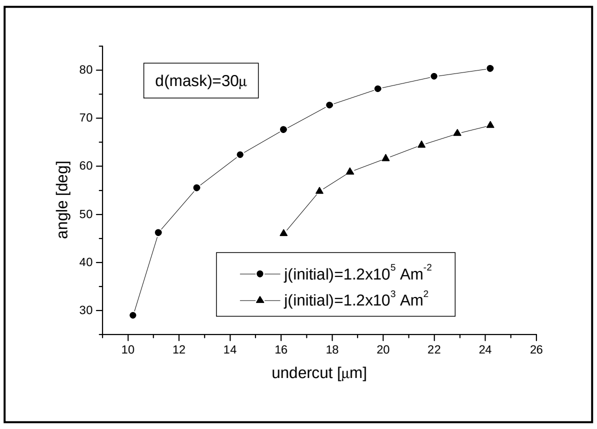

Fig. 2. Through foil etching process: Dependence of the flank angle of a defined structure on the imposed current density (width of the mask 100µm).

ACKNOWLEDGEMENT:
This work is supported within the Kplus program founded by the Austrian Government and Lower Austria

[1] ElSy, ELSYCA NV, Kranenberg 6, 1731 Brussel, Belgium (www.elsyca.com)

[2] A. C. West, C. Madore, M. Matlosz and D. Landolt, J. Electrochem. Soc., Vol. 139, Nr. 2, 1992