

Sm-Co thick films micromolding

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Electrodeposition of Sm-Co has been reported in the past years [1-3], showing that both oxygen contamination, stress and hydrogen adsorption are responsible for weak adhesion on the seed layer and cracks in the films which limits film thickness and magnetic properties.

We present a study of Sm-Co micromolding, leading to the realization of microdots with a high aspect ratio. The films were electrodeposited on a Cu/Cr seed layer sputtered on a SiO₂/Si substrate. The moulds were realized using a 20 μm thick AZ4562 photoresist. The composition of the studied solutions was 1 mol.l⁻¹ of samarium sulfamate, 0.06 mol.l⁻¹ of cobalt sulfamate and 0.18 mol.l⁻¹ of glycine. The composition of the dots was measured using EDS and the thickness was characterized using both SEM and mechanical profilometry.

Former studies in a Hull cell, using a copper cathode, allowed validating the process and the electrolytic solutions [4,5]. The influence of the elaboration parameters on the film composition has been roughly defined. In particular, it was showed that only the continuous current supply can lead to Sm contents larger than 7% in the films. In addition, 1 mm x 1 mm square patterns were realized using thin S1818 photoresist for moulding test on metallized Si substrates and magnetic characterizations. Finally, micromolding with a high aspect ratio has been performed using the thick resist.

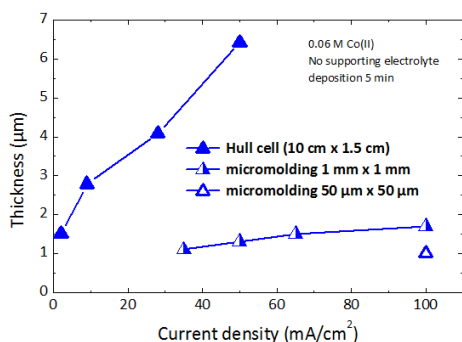


Figure 1: Film thickness as a function of the current density for different pattern dimensions

The results show that the deposition rate and the composition both depend on the dimensions of the pattern (see Fig 1 and 2). It is supposed that the scale factor impacts the ions diffusion from the electrolyte to the cathode surface. In small patterns, this phenomena limits both the samarium deposition and the pH increase, thus the oxygen contamination due to the incorporation of Sm(OH)₃ or the formation of samarium oxide. The interesting point is that by comparison with Hull cell and millimetre-sized moulds, micromolding leads to lower

samarium content at a given current density, but also to lower oxygen contamination for a given samarium content.

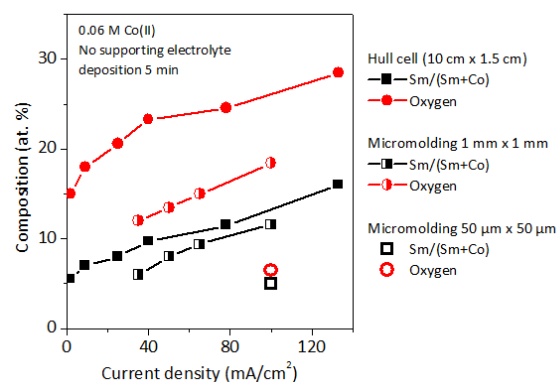


Figure 2: Film composition as a function of the current density for different pattern dimensions

Micromolding of patterns with dimensions varying from 5 μm to 100 μm in diameter was realized. With a deposition time of 30 minutes, a thickness of 8 microns has been reached. However, the large stress in Sm-Co induced by the high deposition rate and hydrogen generation is generally responsible for cracks and peeling of the films, as showed on Fig 3 for large patterns (left). However, SEM observations show that the film adhesion and integrity were ameliorated by the micropatterning, as patterns smaller than 30 μm in diameter are free of defects (Fig 3, right).

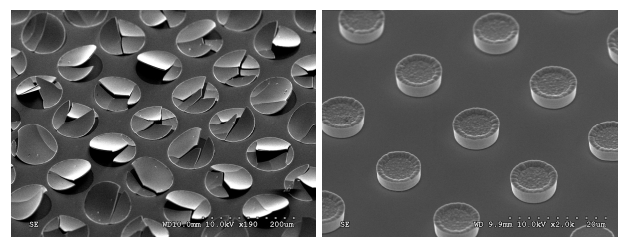


Figure 3: Micromolding of 100 μm (left) and 10 μm (right) patterns

In addition, the micropatterning also ameliorates the thickness uniformity. The Fig 4 compares Hull cell deposition (perpendicularly to the current density gradient direction), 1 mm x 1 mm molding and micromolding. The results show that the current density uniformity over the opening, thus the film composition and thickness, is better for microscopic openings than for macroscopic ones.

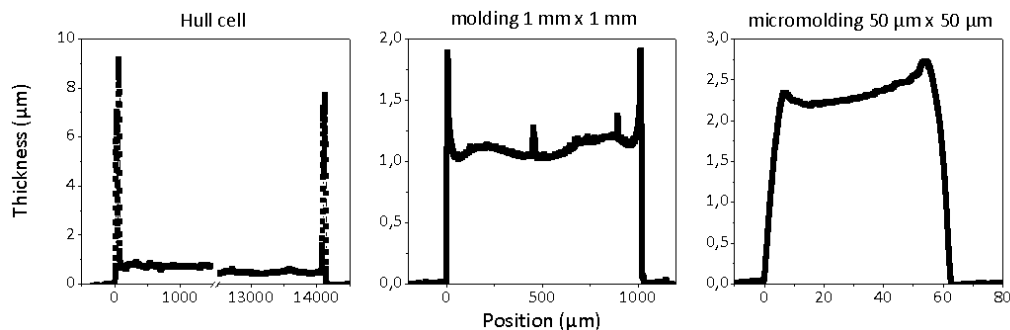


Figure 4: Scale effect on the thickness uniformity

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- [5] K. Chouarbi, E. Dufour-Gergam, M. Woytasik, E. Lefevre and J. Moulin, *J. Electrochem. Soc.* 159(10) D592-D596 (2012).