Time-resolved in-situ STEM study of thermally induced solid-state dewetting in Cu-Ag thin films

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Thermally induced dewetting of thin films is governed by surface energy minimization and results in the formation of agglomerates and islands of the film material on an inert substrate [1]. The control over the dewetting process can therefore enable the production of the nano-structured patterns or nanoparticle arrays. In the present work, thermally activated dewetting of Cu-Ag thin metallic films magnetron sputtered on an amorphous SiNx-substrate was followed by EDS-STEM studies. Multi-dimensional data stacks consisting of BF, DF and HAADF STEM signals complemented by EDS hypermaps were time-resolved acquired on a FEI Talos F200X instrument equipped with a SuperX EDS system. The DC magnetron sputtered Cu-50 at.% Ag films of a total thickness of 40 nm of prepared in one of two routes, (i) co-sputtered and (ii) composed of 20 nm thick Cu and Ag, layers were annealed within the 440 - 550ºC temperature range using a DENSSolution heating holder.

In the present work, the effect of phase separation on the dewetting kinetics and morphology in Cu-50at.% Ag is studied by a comparing the processes in films produced by the two routes. In a co-sputtered Cu-Ag metastable solid solution grain growth and coarsening is accompanied by thermally activated phase decomposition, whereas in the layered films phase separation does not occur. The morphology of the dewetted films can therefore be affected not only by the atomic mobility and stress state of the film but also by decomposition kinetics. A dynamic, time-resolved characterization of the dewetting process as a function of external parameters, initial film morphology, composition, etc., is therefore largely required for the understanding of the contributing mechanisms, which in turn is a pre-requisite for the microstructure design.

Our results are compared to in-situ heating experiments in a single element investigation by Niekel *et al.* [2].

[1] Carl V. Thompson; Annual Review of Materials Research; Vol. 42:399-434 (2012)

[2] Solid-state Dewetting of Metallic Thin Films studied by Advanced in situ Electron Microscopy Techniques. Dissertation. 2017, Friedrich-Alexander-Universität Erlangen-Nürnberg.