Clustering and growth of intermetallic alloy nanodroplets

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The magnetic response of rare earth-iron intermetallic alloy thin films depends on the crystal structure, size and stochiometry of the film's nanocomposites [1].
However, films with nanodroplet-like morphologies, grown with pulse laser deposition exhibit ferromagnetic response even without annealing and nitriding [2]. The magnetism has its origin on the growth of 5-10 nm crystals included inside ~ 50 nm amorphous spherical nanodroplets, which are created in the plume at superheated (non-equilibrium) conditions. The size of the nano-crystalline islands and nanodroplets depends on the target composition the background pressure, the energy and the fluence of the laser and on the distance between the substrate and the target. $Sm_2Fe_{17-x}Ta_xN_{3-\sigma}$ nano-droplets were fabricated in situ in nitrogen background pressure from $Sm_{13.8}Fe_{82,2}Ta_{4,0}$ target by pulse laser deposition using a molecular fluorine laser at 157 nm. The bi/phase nanocrystaline phase was formed during the fast cooling of the nanodroplet on the Ta substrate and in the plume. In this communication the morphology, the stochiometry and the structure of the nanodroplets are analyzed with high-resolution transmission electron microscopy. For a distance of 0.5 cm between the target and the substrate, more than one nano islands were crystallized and agglomerated inside only one nanodroplet, Fig. 1. Furthermore clustering of individual nanodroplets was formed on the Ta substrate, Fig. 2. At longer separation distance nanodroplets of larger size and different stochiometry were formed on the substrate. The thermodynamics of the system for the optimum conditions of nanodroplet formation is discussed.

References:

[1] K. Žužek, P. J. McGuiness, S. Kobe, Magnetic monitoring of the nitriding process in Sm-Fe-Ta-based alloys. *IEEE Trans. Magn.* 39, 2983-2985, 2003.
[2] S. Kobe, E. Sarantopoulou, G. Dražić, J. Kovač, M. Janeva, Z. Kollia, A.C. Cefalas. To be published in *Appl. Surf. Science* in 2007.

Figures:

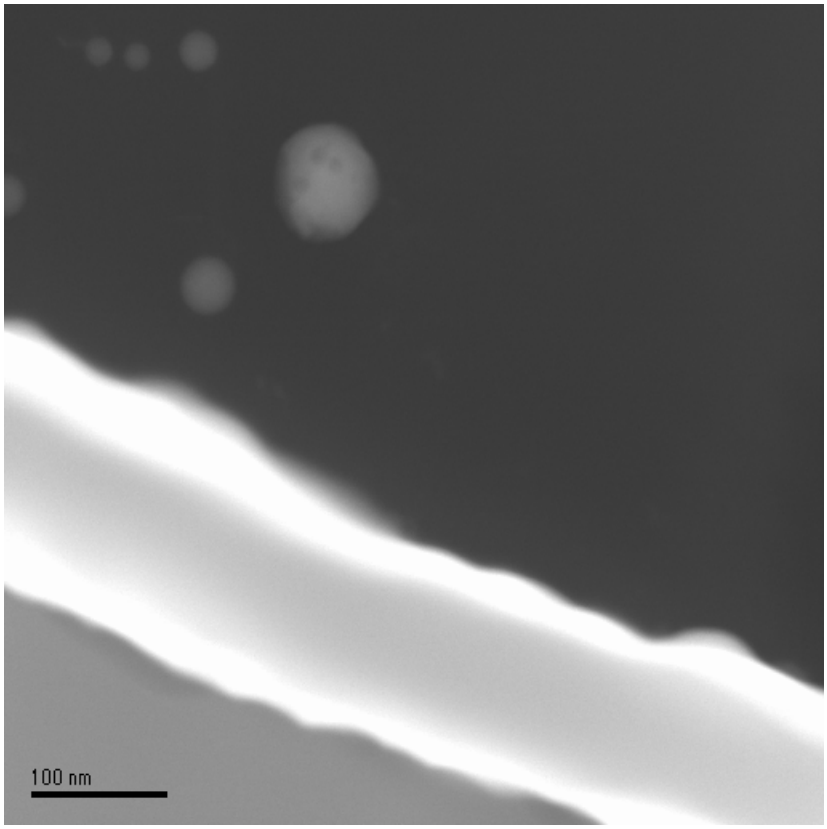

Figure. 1 A TEM image of a single ~ 62 nm wide $Sm_2Fe_{17-x}Ta_xN_{3-\sigma}$ nanodroplet on a Si substrate sputtered with Ta. Four 15 nm nano-crystal islands were grown on the top of the Ta substrate surrounded by the amorphous material.

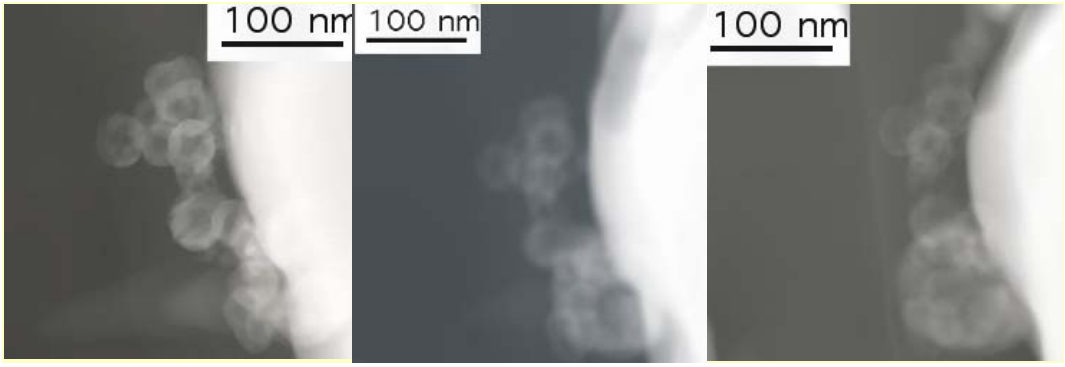

Figure 2. TEM image of clusters of $Sm_2Fe_{17-x}Ta_xN_{3-\sigma}$ nanodroplets on a Si substrate coated with Ta.