Solid-state dewetting of FePd thin films into magnetic nanoparticles.

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Magnetic particles of controlled size located on a substrate are of widespread technological interest in different areas such as catalysis, photonics, sensing and for fabricating multifunctional magnetic systems. Solid-state dewetting of magnetic thin films is a promising bottom-up method for producing magnetic nanoparticles on a large scale. The spontaneous agglomeration of a metallic thin solid film on a substrate into an assembly of particles with defined shape and size is a controllable process by means of annealing parameters (temperature and time), substrate type and film composition and thickness [1,2]. In this work, the dewetting method is exploited to fabricate magnetic FePd particles starting from continuous Fe_xPd_{1-x} ($60 \leq x \leq 80$) thin films of different thickness deposited by sputtering on a silicon oxide substrate. To promote dewetting, the thin films are subsequently annealed in furnace in vacuum at selected temperatures (T_A = 750 °C, 820 °C and 870 °C), for different time (t_A) in the interval 0 – 100 minutes. The void incubation time and the dewetting activation energy for both film thickness and composition have been analysed by Johnson-Mehl-Avrami (JMA) model to control the transformation. The process has been followed by acquiring scanning electron microscopy (SEM) images of annealed FePd samples to investigate the progressive steps of dewetting (see Fig. 1a). Particles shape factors such as density, circularity and equivalent diameter have been analysed as a function of the annealing parameters. Magnetic hysteresis loops have been measured to investigate the evolution of coercivity, initial susceptibility and remanence during dewetting leading to particles formation (see Fig. 1b). First Order Reversal Curves (FORCs) provide an insight on the irreversible magnetisation processes that depend on the film nanostructuring (Fig. 1c and d). Upon completion of the dewetting process into nanoparticles, the magnetic measurements point to the development of a system composed of mostly non-interacting particle arrays. Subsequently, the particles have been removed from the substrate and their properties investigated again in powder form.

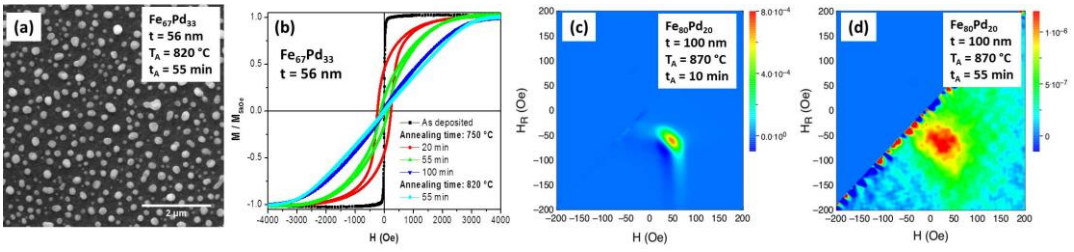

Figure 1. (a) SEM image of dewetted $Fe_{67}Pd_{33}$ sample. (b) Evolution of hysteresis loops during the dewetting process. (c,d) FORC colour-maps of $Fe_{80}Pd_{20}$ samples annealed for 10 min (c) and 55 min (d).

[1] C. V. Thompson, *Annu. Rev. Mater. Res.***42** (2012)

[2] R. Esterina, X. M. Liu, A. Adeyeye, C. A. Ross, W. K. Choi, *J. Appl. Phys.* **118** (2015)

Funding of this work by SELECTA – ETN (grant no. 642642) is acknowledged.