doi: 10.1017/S1431927609093167
Microsc Microanal 15(Suppl 2), 2009

Microstructure of Magnetic Nanoparticles Patterned on SiO_2 Templates via Laser Annealing.

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Well-defined magnetic nanoparticle arrays have recently attracted considerable interest for applications in magnetic recording media and as catalysts for manufacturing carbon nanotubes[1,2]. It has recently been established that a thermal annealing of metal thin films can be used to fabricate gold nanoparticle arrays by inducing metal thin film dewetting[3]. This research investigates Co, Ni, and Co-Pt alloy nanoparticles that are fabricated from metal thin films by liquid-state dewetting, using a laser irradiation: the microstructures are investigated as well.

SiO_2 substrates with 200 nm-periodic topography were used. The topographic templates were made via an interference laser lithography technique. The Co and Ni thin films were deposited by a Nd:YAG pulsed laser with a wavelength 266nm, while the Co-Pt thin film was deposited by RF magnetron sputtering onto a smooth and topographic template. Pulsed-lasers of various energy densities were irradiated onto metal thin films for dewetting. Microstructures of nanoparticles were observed using HR-SEM (high-resolution scanning electron microscopy) and HR-TEM (high-resolution transmission electron microscopy). Cross-section samples were prepared for TEM observation using an FIB (focused ion beam).

Figure 1 shows the appearance of Co nanoparticles dewetted onto a smooth template. The completion of the dewetting process required a critical laser energy density greater than $80 mJ/cm^2$. The detailed dewetting mechanism is concident with the agglomeration mechanism of liquid films (Figure 1); that is, spinodal dewetting instability causes fluctuations in thickness when attractive intermolecular forces exceed the interfacial tension. The capillary effect pulls a liquid, resulting in a higher curvature radius and the formation of small particles. On the surfaces of the templates with periodic topographies, nanoparticles successfully self-assembled to form periodic arrays of three types (Figure 2).

The nanoparticles fabricated by laser annealing appeared to conform to surface topography, due to the complete melting during laser irradiation. Figure 3 shows a cross-sectional image of nanoparticles observed by HR-TEM. The Co nanoparticles consist of fine grains, with instances of twins visible in the image. The Ni nanoparticles formed larger grain sizes than Co. In this study, the collective behavior of Co, Ni, and CoPt nanoparticles is examined and discussed in light of their microstructures and particle shapes. The data from this investigation suggest that the pulsed laser annealing may be a promising technique for the fabrication of nanoparticles arrays.

References

[1] J.I. Martin, J. Nogues, K. Liu, J.L. Vicent, I.K. Schuller, *Journal of Magnetism and Magnetic Materials* 256 (2003), p.449.
[2] C.A. Ross, M. Hwang, M. Shima, J.Y. Cheng, M. Farhoud, T.A. Savas, Henry I. Smith, W. Schwarzacher, F.M. Ross, M. Redjdal, F.B. Humphrey, *Physical Review B*, 65 (2002), p.144417.
[3] A.L. Giermann, C.V. Thompson, *Applied Physics Letters* 86 (2005), p.121903.

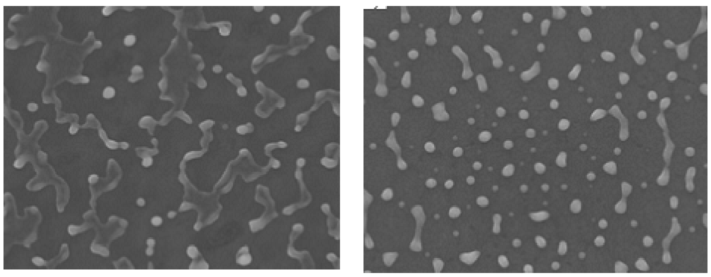

FIG 1. SEM images showing the agglomeration of Co films induced by pulsed-laser dewetting.
(a) laser energy: 80mJ/cm^2, 100 shots; (b) laser energy: 100mJ/cm^2, 100shots

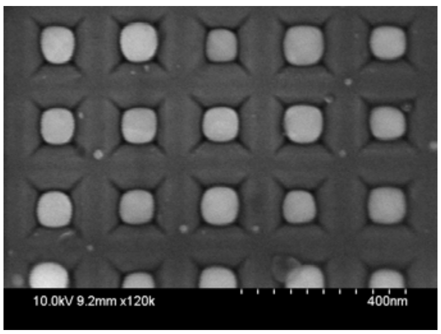

FIG. 2. The top-view image of Ni nanoparticles fabricated by pulsed-laser dewetting.

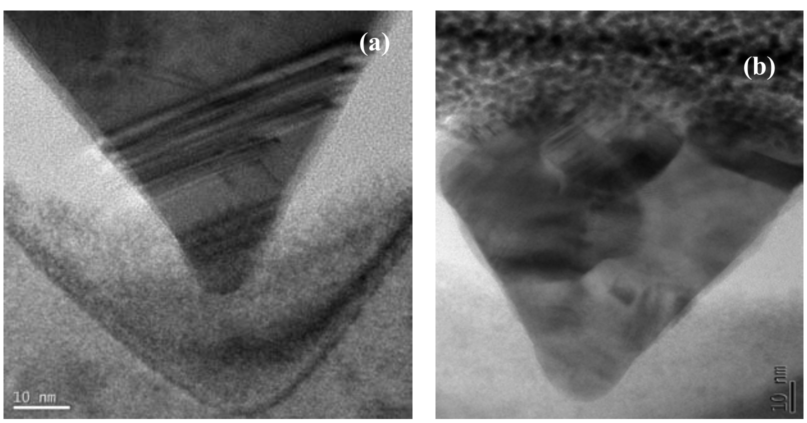

FIG. 3. Cross-sectional HR-TEM images showing Co and Ni nanoparticles fabricated by laser dewetting.
(a) Co nanoparticles
(b) Ni nanoparticles

https://doi.org/10.1017/S1431927609093167 Published online by Cambridge University Press