MFM study of Néel wall pinning by diluted arrays of antidots in Co-based amorphous films

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The study of nanostructured magnetic films is a field of broad interest in recent years [1] due to the well known possibility to tailor their magnetic properties by a very small scale. In this sense, ordered arrays of magnetic dots have been widely researched for their possibilities in high density magnetic recording. As well as this, it is worthy to note that nanostructuration processes in continuous thin magnetic films allows to introduce an extra spatially-dependent shape anisotropy. This capability could be used, for example, to fabricate concentrated arrays of holes in magnetic thin films for applications in ultrahigh magnetic density recording [2], so the problems associated with the superparamagnetic limit that appears in small particle arrays can be avoided. Films with diluted enough antidot concentration can be used as a good model system to understand the details of domain wall pinning by non magnetic inclusions [3].
On the other hand, the nanostructuration process affects macroscopic properties such as magnetoresistance, coercive field or magnetic anisotropy. Thus, depending on antidot density (concentrated or diluted arrays [4]) and on array geometrical characteristics, nanostructuration can be used as a tool to engineer the magnetic properties of thin films in a wide range of scales.
In this work we have studied the magnetic configuration of several ordered arrays of antidot fabricated by electron beam lithography and Ar^+ etching on amorphous soft-magnetic $Co_{86}Zr_{14}$ and $Co_{73}Si_{27}$ alloys thin films (400Å thick) grown by co-sputtering. The choice of these two materials allows us to compare the effect of patterning on two films with very similar uniaxial anisotropy but very different saturation magnetization. Arrays will be prepared in diluted regime, i.e. with large interhole distances compared to the antidot size, so the lithography-induced anisotropy is only a small perturbation on the original well defined uniaxial anisotropy of these films. Several samples were fabricated varying the array spacing and aspect ratio (10x10μm, 10x5μm, 5x10μm).The main aim of this study is to understand the interplay between material parameters and patterning induced effects on coercivity and domain wall pinning.
Vector hysteresis loops have been measured by Transverse Magnetooptical Kerr effect (MOTKE) as a function of the applied field direction. An enhancement in coercivity is only found for the lower magnetization films ($Co_{73}Si_{27}$) for fields applied close to the intrinsic film easy axis. These results will be discussed in terms of the characteristics of the Néel walls involved in the reversal process.
The closure domain configuration around each antidot is characterized with MFM images revealing that in this diluted regime the patterned holes act as individual defects. Differences between both rectangular arrays in $Co_{73}Si_{27}$ film have been characterized by MFM, showing radically different pinning capabilities (see Figs. 1 (a) and (b)).
MFM measurements reveal, in addition, the presence of Néel domain walls on $Co_{73}Si_{27}$ samples and the capability of interact with them. The evolution of 180º Néel walls is studied as they travel across the antidot pattern (see Fig. 1(c)). Wall pinning induced by antidot arrays is also observed and will be discussed in terms of the linear density of antidots along the wall.
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References:

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Figures:

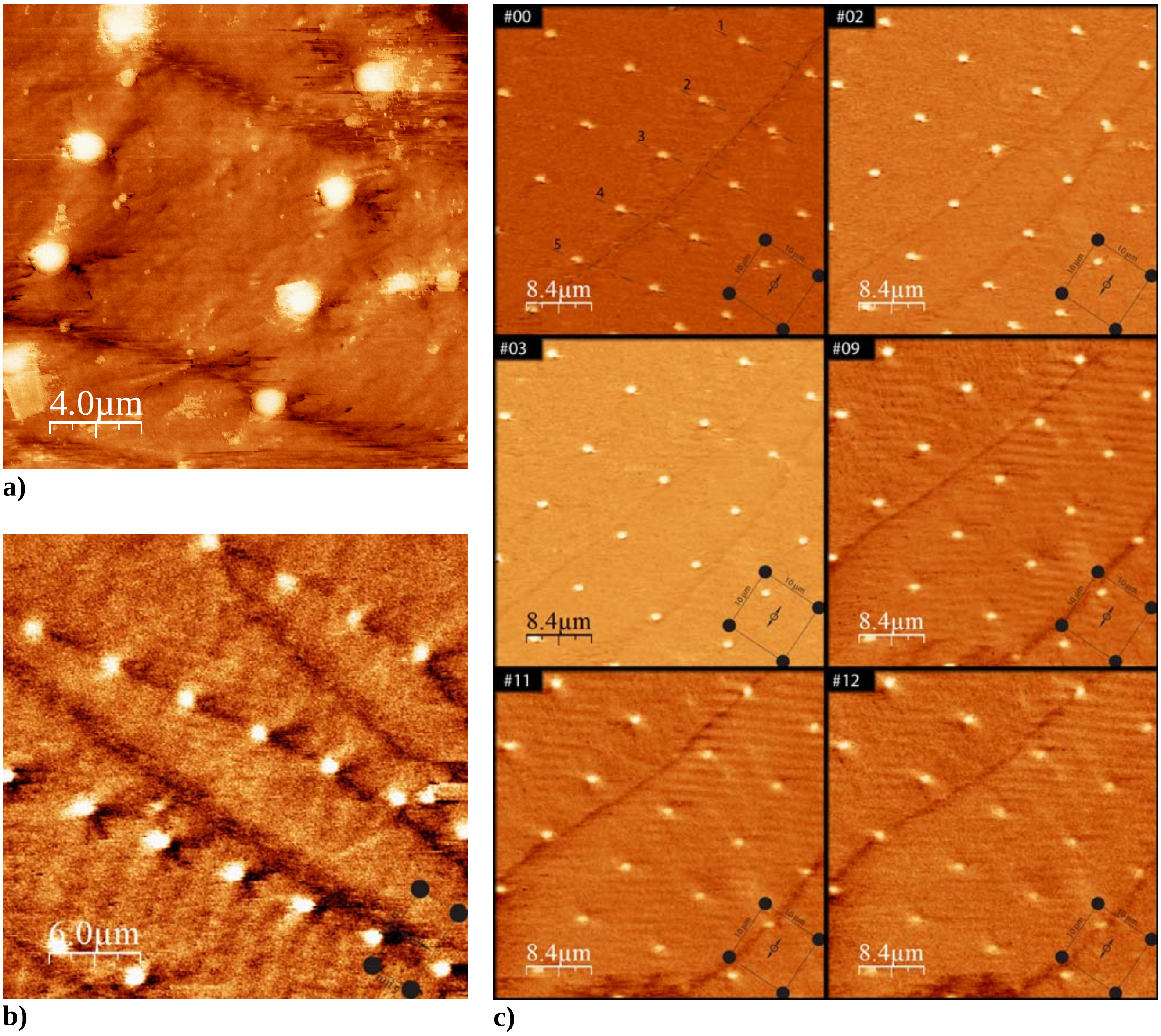

Fig 1: MFM images of antidot arrays on $Co_{73}Si_{27}$ showing different pinning effect depending on the antidot array geometry and the easy magnetization axis of the continuous thin film.