Poster

MAGNETIC FORCE MICROSCOPY OF MIXED SYSTEMS: DOES IT WORK?

Cristina S. Neves[a], *Pedro Quaresma*[a,b], *Patrícia A. Carvalho*[c], *João Pedro Araujo*[d], *Peter Eaton*[a*] *and Eulália Pereira*[a]

a REQUIMTE/Faculdade de Ciências, Universidade do Porto, R. Campo Alegre 687, 4169-007 Porto, Portugal
b CIGMH/Departamento de Ciências da Vida, FCT-UNL, 2829-516 Caparica, Portugal
c Departamento de Engenharia de Materiais, IST, Av. Rovisco Pais 1049-100 Lisboa, Portugal
d IFIMUP, R. Campo Alegre, 678, 4169-007 Porto, Portugal
* Corresponding author: peter.eaton@fc.up.pt

Magnetic force microscopy (MFM) is a variant of atomic force microscopy (AFM), in which a probe with a magnetic coating is used, conferring sensitivity to the magnetic fields of the sample. In order to obtain useful information, it is necessary to separate the magnetic forces acting on the probe from short and long range non-magnetic forces. A variety of methods have been described, but in the most commonly employed configuration, the surface topography is measured by normal AFM methods, followed by lifting the probe from the surface, and scanning at a fixed height above the sample, in order to remove short-range nonmagnetic forces acting on the probe. The magnetic fields are detected by measuring the phase shift of the oscillating probe (this is the so-called lift mode). This technique is widely employed to study large (>50nm) magnetic domains in flat surfaces, and provides useful information under these circumstances.
Recent work has established that this method may also be appropriate to characterise the magnetic properties of superparamagnetic nanoparticles [1], although work on using MFM to characterize nanoparticles has been scarce until now, presumably due to the difficulties in detecting very small magnetic domains with this technique [2]. Unfortunately, there are a large number of difficulties with this technique, not least of which is uncertainty about the actual mechanism of contrast formation [3, 4]. In practical terms, for MFM imaging of MNPs in ambient conditions the major problem is the existence of non-magnetic forces, which can give rise to contrast in the phase-shift images, even without any magnetic interaction [2, 5]. The work described in this poster was carried out in order to determine whether the contrast seen in lift mode MFM is really of magnetic origin. Furthermore, we aimed to use MFM to differentiate between magnetic and nonmagnetic materials, and ultimately enable measurement of properties of MNPs on a single particle level. In order to help us to understand better the response of MFM under these conditions, we have applied it to the study of a range of both magnetic and nonmagnetic nanoparticles.

Magnetic particles of about 10 nm diameter produced by thermal decomposition of iron precursors were studied by lift mode MFM under an external magnetic field. By the measurement of phase shift at different lift heights, the expected dependence of the phase shift *vs* lift height was verified. Furthermore, in order to test the ability to distinguish magnetic interactions from non magnetic ones a mixture of Au nanoparticles (17 nm) and Fe_3O_4 nanoparticles (33 nm) was imaged. Signal decay *vs* distance was verified as well as the inversion of the phase signal when comparing Au nanoparticles with Fe_3O_4 nanoparticles showing that a distinguishable response between the two materials could be observed. The samples were examined both in the presence and absence of an external magnetic field, further enabling our understanding of the mechanisms of contrast formation by this technique. The results of the study increase our comprehension of MFM, and allow the use of this technique to probe the magnetic properties of magnetite-based nanoparticles, enabling further study in more complex systems in the future.

References:

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Figures:

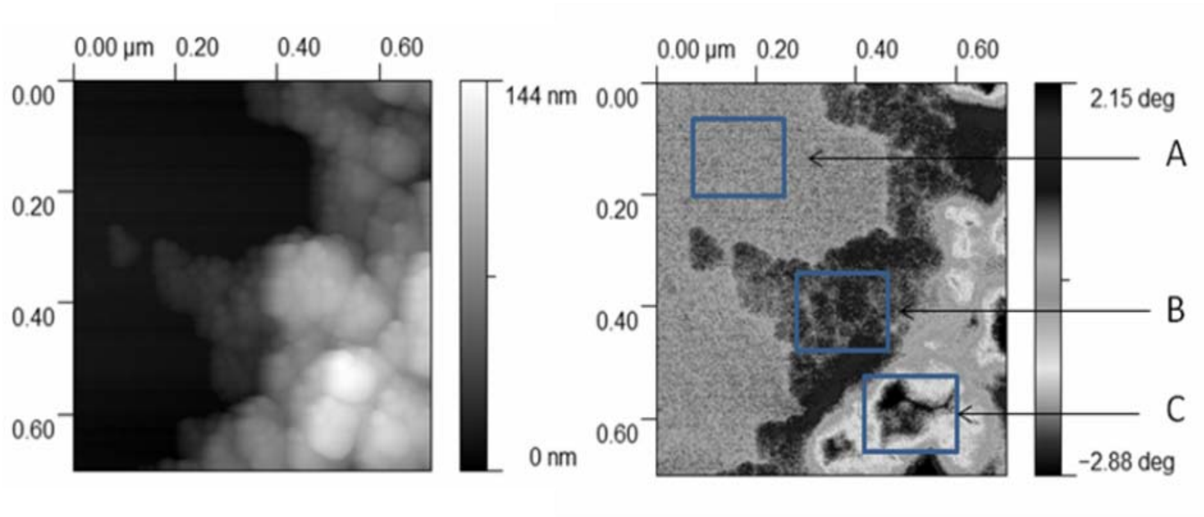

Figure **1** – Left: AFM height image of a mixture of gold and magnetite nanoparticles. Right: MFM phase shift of the same area measured in lift mode, showing contrast between mica substrate (A), gold (B) and magnetite (C) nanoparticles.

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