$Ni_{80}Fe_{20}$ nanodisks by nanosphere lithography for biomedical applications

P. Tiberto[1], G. Barrera[1,2], F. Celegato[1], M. Coïsson[1], G. Conta[1,2], F. Vinai[1], K. Martina[3], M. Caporaso[3], L. Serpe[3], R. Canaparo[3]

[1]INRIM, Electromagnetism Dept, Torino, Italy
[2]Chemistry Dept, Università di Torino, Torino, Italy
[3]Dipartimento di Scienza e Tecnologia del Farmaco, Università di Torino, Torino, Italy

Magnetic nanoparticles have been intensively studied for applications in data storage, contrast enhancement agents in magnetic resonance imaging, drug delivery systems and magnetic hyperthermia.
The magnetic moment is exploited for target-directed delivery, detection, separation, and manipulation. A number of recent publications describe the preparation of composite materials in which every component of a hybrid plays an equally significant role in biorecognition and targeting, multimodal imaging, and therapy.
The intrinsic difficulty of controlling nanoparticle dimension leads to not easily tunable magnetic properties. Bottom-down nanolithography process allows the production of nanodisks having different diameter and ferromagnetic properties.
In this work, the fabrication process together with room-temperature magnetic behavior of $Ni_{80}Fe_{20}$ nanodisk suspended in ethanol solution are presented. Arrays of nanodisks were obtained by polystyrene nanospheres nanolithography, as shown in the scheme reported in Fig. 1a together with the corresponding SEM images. Such a process is based on the self.-assembling of commercially available polystyrene nanospheres (starting diameter 800 nm) on continuous thin films (thickness 30 nm) sputtered on a layer of optical resist. After depositing a monoloyer of nanospheres on the film surface, spheres diameter is reduced by plasma in Ar. Subsequently, magnetic material among the nanospheres is removed by sputter-etching. The removal of the remaining spheres is performed by sonication. At this stage, the resist layer is dissolved in aceton resulting in freely nanodisks. After the complete remove of the polymer by several washing the nanodisks are dispersed in ethanol.
AFM/MFM images have been measured on all samples before the removal process. Magnetic vortex magnetisation process have been observed. Room-temperature magnetic hysteresis curves have been recorded at several stages of the process, as shown in Fig. 1b. The continuous film display a typical soft magnetic behaviour. The patterning process lead to a hysteresis loop having the shape typical of magnetisation vortex nucleation with a higher coercive field. Free-standing nanodisks are characterised an unsaturating magnetisation behaviour together with a non-zero coercivity that can be related to the high nanodisks diameter (around 600 nm).
To assess, in biomedical application, the suitability of the nanodisks in targeted drug delivery, chemical bioderivativation has been taken into account. Bioderivatization was aimed to the production of a nanoscaled functional material that combine multiple functionalities for enhanced therapeutic efficacy. The *in vitro* toxicity assessment of the nanodisks will be discussed.