## 2D-FDTD simulations of NSOM microscopy with magneto-optical capabilities

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The study of magnetic nanostructures has a great interest from both, fundamental and technological point of view. At the nanoscale standard characterization tools can become uselessness and new kind of techniques are needed. Scanning probe microscopes (SPM) are very suitable in this length range for manipulation and characterization. The most popular SPM used to explore the magnetic properties is the MFM (Magnetic Force Microscopy) technique. The main problem of this microscopy system is the magnetic tip: it can strongly modify the magnetization configuration of the sample under study [1]. Another SMP technique called NSOM (Near field Scanning Optical Microscopy) has a great interest because it avoids this magnetization modification problem [2]. The NSOM with magneto-optical capabilities is a valuable technique to study the magnetic properties of the nanostructures as the conventional magneto-optical characterization does at larger scales [3].

Our group has been working with a M-O NSOM for the last years and the develop presented in this contribution is focused to understand certain aspects of our M-O NSOM experiments in order to get a deep understanding of the origin of the image formation. For this purpose we have developed a code based on the 2D-FDTD algorithm for the Maxwell equations [4]. As all possible materials need to be simulated with this algorithm we have had to extend the FDTD code to take into account metals with magneto-optical response. The main output of the code are the amplitude distributions over the simulation space of the Electric and Magnetic fields [Fig1]. With the 2D fields configuration we can simulate the Transversal Magneto Optical Kerr Effect (TMOKE) at the nanoscale [5].

First of all we have simulated the dependence of the magneto-optical response of a cobalt thin layer both uncoated and coated with a non magneto-optical media. The purpose of the last coating is to enhance the mageto-optical response from the Co layer at nanometric scale [6]. We have varied the magneto-optical response for different cobalt layer thickness and several values of the collector's angle. We have found a strong and non monotonic dependence of the magneto-optical response with the angle [Fig2].

In a second numerical experiment we have simulated a NSOM scanning over an inhomogeneous flat surface. The sample consists in a non magnetic matrix with cobalt stripes embedded inside. The objective of this experiment is to show the submicrometric resolution of the NSOM technique far above the Rayleigh's criterion.

### References

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**Figure1**

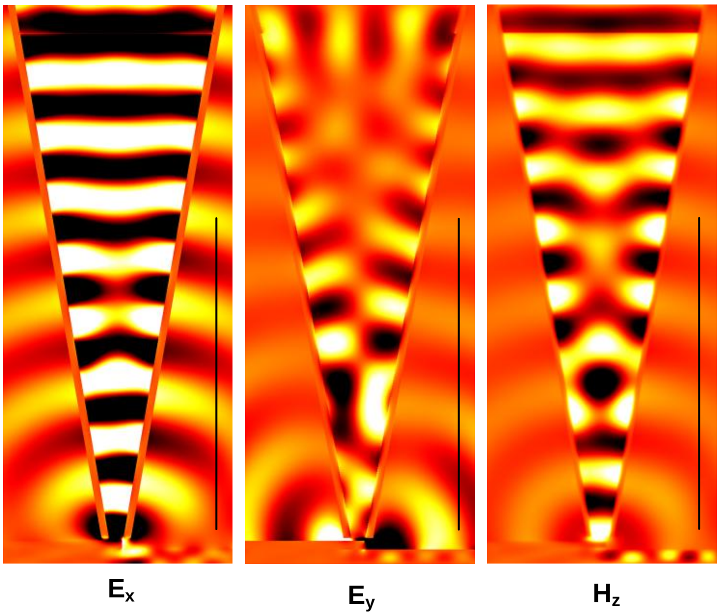


*Fig.1 Amplitude distribution of the different Electric and Magnetic fields components over the simulation space. The black line at the right represents the collector's position.*

**Figure2**

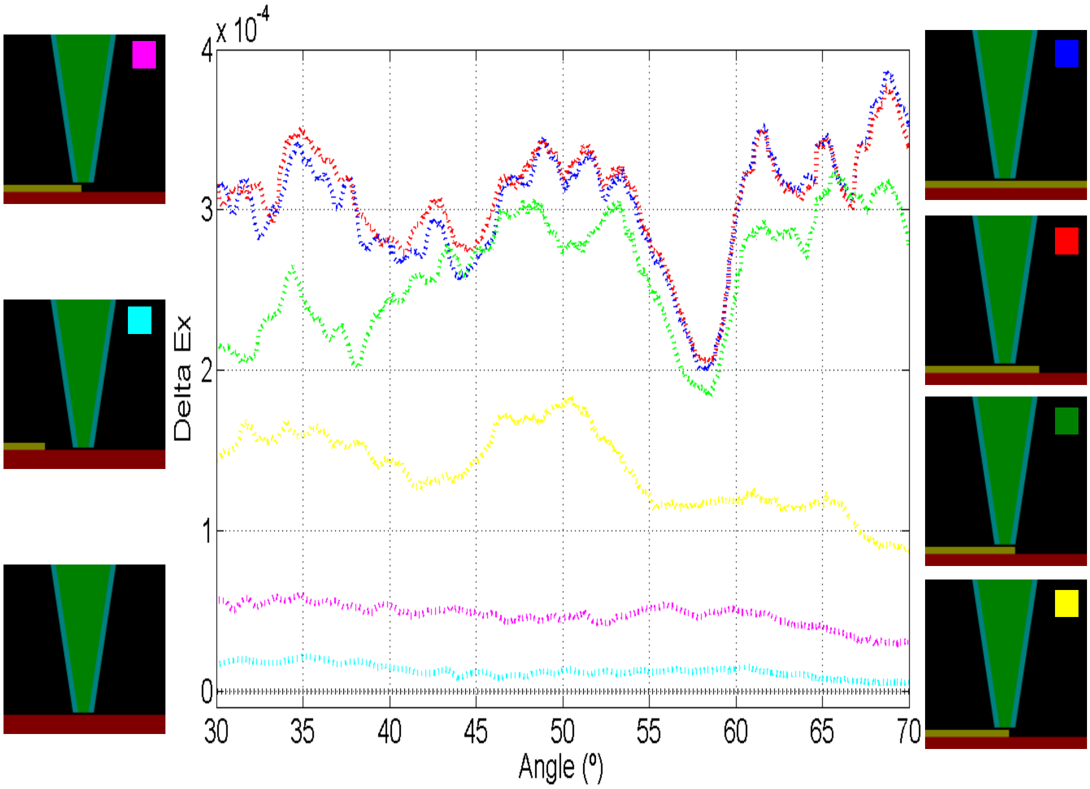


*Fig.2 Dependence of the magneto-optical response measured as a function of the detector's angle for several position of the tip over the magneto-optical layer.*