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Hybrid Bimodal Magnetic Force Microscopy

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Abstract : Magnetic Force Microscopy (MFM) is an Atomic Force Microscopy (AFM) technique that characterizes, at a nanometric scale, the magnetic properties of ferromagnetic materials. Conventional MFM works by scanning in two different AFM modes. The first one is tapping mode, in which the cantilever has short-range force interactions with the sample, with the purpose to obtain the topography. Then, the lift AFM mode starts, raising the cantilever to maintain a fixed distance between the tip and the surface of the sample, only interacting with the magnetic field forces of the sample, which are long-ranged. In recent years, there have been attempts to improve the MFM technique. Bimodal MFM was first theoretically developed and later experimentally proven. In bimodal MFM, the AFM internal piezoelectric is used to cause the cantilever oscillations in two resonance modes simultaneously, the first mode detects the topography, while the second is more sensitive to the magnetic forces between the tip and the sample. However, it has been proven that the cantilever vibrations induced by the internal AFM piezoelectric ceramic are not optimal, affecting the bimodal MFM characterizations. Moreover, the Secondary Resonance Magnetic Force Microscopy (SR-MFM) was developed. In this technique, a coil located below the sample generates an external magnetic field. This alternating magnetic field excites the cantilever at a second frequency to apply the Bimodal MFM mode. Nonetheless, for ferromagnetic materials with a low coercive field, the external field used in SR-MFM technique can modify the magnetic domains of the sample. In this work, a Hybrid Bimodal MFM (HB-MFM) technique is proposed. In HB-MFM, the bimodal MFM is used, but the first resonance frequency of the cantilever is induced by the magnetic field of the ferromagnetic sample due to its vibrations caused by a piezoelectric element placed under the sample. The advantages of this new technique are demonstrated through the preliminary results obtained by HB-MFM on a hard disk sample. Additionally, traditional two pass MFM and HB-MFM measurements were compared.

Keywords : magnetic force microscopy, atomic force microscopy, magnetism, bimodal MFM
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