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A new acoustic microscope based on evanescent waves

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Abstract – A new acoustic microscopic technique based on evanescent waves is proposed in this work. The system employs an equilateral prism of silicone where longitudinal acoustic wave velocity is about 1000 m/s and shear acoustic wave is much attenuated. First measurements showed that the instrument can operate in two modes according to the observed surface: “transmission” and “reflection”. Two transducers operating at 1 MHz were placed in the up and lateral faces and in the two lateral faces transmission and reflection measurements, respectively. Results have shown that the resolution of this new acoustic microscope can overcome the Rayleigh’s criterion.

In the last two decades, the development of new materials and nanotechnologies is directly associated with the improvement or invention of new characterization techniques. The arrival of new kind of microscopes, like scanning tunneling microscope (STM), atomic force microscope (AFM), scanning tunneling optical microscope (STOM), magnetic force microscope (MFM), etc., was undoubtedly the most important step to observe materials in micrometer and nanometer scales and determine their physical properties in these levels [1-3]. Regardless of this great development, until today there is not an acoustic microscope based on evanescent waves as STOM for optics. Thus, the aim of this work is to present a new concept of acoustic microscope based on acoustic evanescent waves in order to obtain a better resolution than that given by the Rayleigh’s criterion (diffraction limit).

The project of the scanning tunneling acoustic microscope (STAM) is based on the STOM and it differs from the others probe acoustic microscopes proposed in the literature [4-6] because only evanescent acoustic waves are taken into account. Some important differences between acoustic and electromagnetic waves must be considered in the microscope assembly. Contrary to electromagnetic waves, acoustic waves need a medium to propagate and two bulk modes (longitudinal and shear modes) are present and mixed in solids. Consequently, there are two critical incidence angles associated with each propagation mode. Moreover acoustic waves in solids are faster than in liquids and the corresponding refraction indexes are inverted in relation to the electromagnetic case. In order to reduce the complexity of these acoustic characteristics, the system employs an equilateral prism of silicone (see Fig. 1) where longitudinal acoustic wave velocity is about 1000 m/s and shear mode is so attenuated. The equilateral shape ensures that longitudinal acoustic wave will be always in critical incidence for all materials placed in the up face of the prism and with a longitudinal velocity higher than 1200 m/s. Depending on the relative position between the transducer and the detector, the microscope can operate in transmission mode or reflection mode. Obviously, these terms are due to the geometric configuration and are not associated with the evanescent waves. The two transducers operate at 1 MHz and they were placed as showed in Figs. 1 and 2. A water drop and a glass plate were used as samples and the first results showed that the evanescent acoustic waves can be detected and the resolution of this new acoustic microscope overcomes the diffraction limit.

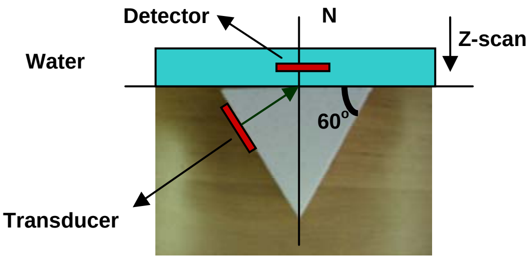

Figure 1: Schematic configuration of the acoustic microscope based on evanescent acoustic waves operating in transmission mode.

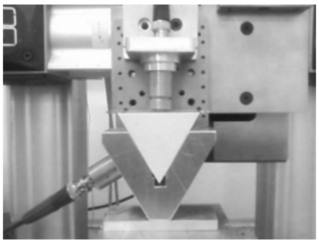

Figure 2: Photo of the STAM operating at 1 MHz. Operation in reflection mode is obtained with another detector placed on the right side of the base.

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