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Method for increasing sensitivity of shear-force distance control for scanning near-field microscopy

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Abstract

Scanning-near field optical microscopy requires a distance control mechanism. In most cases, it is based on the shear-force detection. In this paper we report how the performance of the shear-force detection based on the most common nonoptical approach, a Quartz tuning fork, can be improved. Our approach is based on exciting oscillations in just one arm of the fork, not two. This approach reduces the response time of the shear-force detection system. We also introduce an ultra-sensitive system with a long free fiber tip.

Keywords: Shear-force distance control; Scanning near-field miscroscopy

1. Introduction

Shear-force detection is commonly used as the key method for distance control in near-field optical microscopy and related techniques. It is based on exciting probe oscillations parallel to the surface and monitoring their dependence on probe–sample separation. A dissipative interaction between them dumps the oscillations. The detection of the oscillations can be performed optically by an interferrometric method or by measuring the intensity of reflected or shadowed beam spot. Numerous variations of optical detection system have been proposed [1]. More recently, various nonoptical methods were introduced as they offer some important advantages over the optical ones. These methods are based on, e.g., piezoelectric tuning fork [2], use of capacitance detectors [3], detection of voltage induced in a secondary piezo element glued to the holder or directly to the fiber [4]. Method based on tuning fork is becoming the dominant one. However, in comparison to other methods, it has relatively long time constant of relaxation processes, which limits the speed of shear-force feedback system. In this paper we modified the configuration employing Quartz oscillator to reduce the response time and to increase the sensitivity of the system.

2. Linear model of tuning fork oscillator in standard configuration

In the original design [2] the fork base is glued to a piezo, which is excited at the main resonance frequency. The probe is glued to one of the arms. In the main mode the arms oscillate with opposite phase, the forces between the two arms are much

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