

A MEMS-BASED NANOPOSITIONER FOR ON-CHIP ATOMIC FORCE MICROSCOPY

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A new MEMS-based parallel kinematics nanopositioner is presented, being designed, fabricated and implemented using the MEMSCAP Silicon on Insulator process. The device was used as the scanning stage of an Atomic Force Microscope (AFM).

Nanopositioners have been used in applications including scanning probe microscopy [1], atomic force microscopy [2] and ultrahigh-density probe storage systems [3,4]. The nanopositioner reported here is designed for use in atomic force microscopy wherein the scan table is made to track a raster pattern in the x and y plane while a micro-cantilever conducts measurements in the z direction. The device is designed such that the position of the stage can be estimated from the input voltage with a high degree of confidence. The layout of components has been designed such that unwanted resonance modes are shifted to frequencies far from the operating frequencies.

The design consists of a central positioning stage, actuating combs, connecting springs, and the substrate base, as shown in Figure 1. Two actuating combs are found at the edges of the device for actuating the device in the x and y directions. These are connected to the substrate with beam springs that are oriented perpendicular to the direction of actuator movement. The central positioning stage is connected to the actuating combs using beam springs which are oriented parallel to the direction of actuation of the comb.

For accurate positioning of the actuated stage, it is desirable to have a high stiffness in the out of plane (z) direction. The stiffness of the device in the x and y planes is chosen such that the displacement due to the maximum applied voltage is equal to the desired stroke of the nanopositioner. To prevent rotational oscillations of the stage within the plane, a high degree of torsional rigidity is required about the z -axis.

Earlier nanopositioner stage implementations have suffered from low torsional rigidity in both the actuating combs and the positioning stage. By using a layout that uses many thin beam flexures, the stability of the positioner is increased.

The nanopositioner was characterized using a Polytec MSA-400 Micro System Analyzer and was then used as the scanning stage of a commercial AFM (NTMDT-NTEGRA) to perform an open-loop scan. The nanopositioner's scan table was designed with repeated features 500nm high, spaced 5um apart as shown on the bottom right corner of Figure 1. The image produced from the AFM scan is shown in Figure 2.

These initial investigations establish the capability of this device to function as the nanopositioning stage of a miniaturized atomic force microscope. This design has opened the scope for the development of feedback controllers and high accuracy low frequency sensing interface circuitry. These aspects are currently being investigated based on this device, and with the view to realize high-speed atomic force microscopy on a chip.

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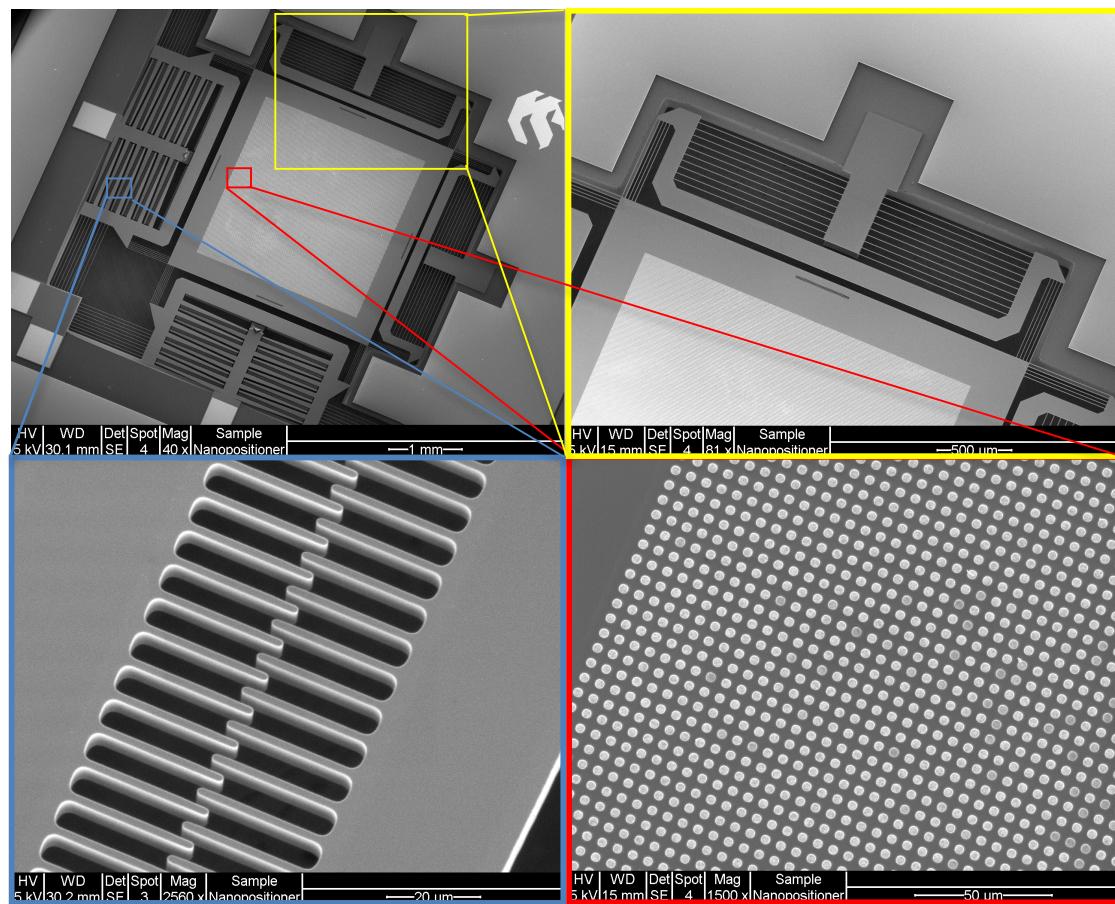


Figure 1 MEMS Nanopositioner

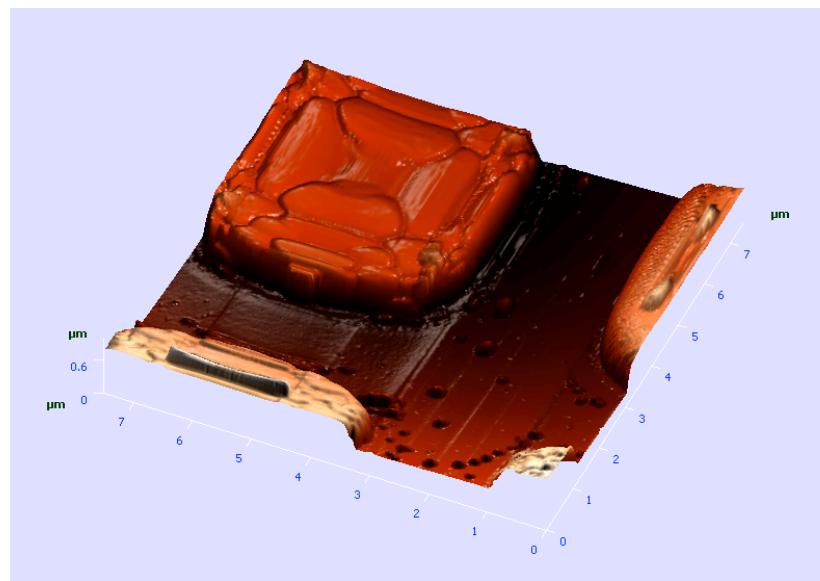


Figure 2 Atomic Force Microscope image of the features of the nanopositioner.