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磁気共鳴力顕微鏡用シリコンナノワイヤーカンチレバー

Silicon Nanowire cantilever for Magnetic Resonance Force Microscopy

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Introduction: Magnetic resonance force microscopy (MRFM) is a magnetic resonance imaging technique based on scanning probe microscopy. In terms of force sensitivity, the structure of the cantilevered sensor should be narrower [1]. Recently, Si nanowire cantilevers with a high quality factor have been reported for use of force detection [2]. In this research, Si nanowire cantilevers have been developed for MRFM. The key of the research is the batch fabrication process with the design of a magnetic material (nickel) on the cantilever.

Experiments: The Si nanowire cantilevers are fabricated from a silicon on insulator wafer with a 200nm-thick device layer. The nanocantilever structure is patterned by electron beam lithography, and the top Si layer is etched by fast atom beam using SF_6 gas, a 500-nm-thick nickel layer is deposited using DC facing targets sputtering, and magnet pattern is formed by lift-off process. The handling Si is etched from the back side using deep reactive ion etching. The box-layer of SiO_2 is etched and the structure is released by vapor HF etching.

Results: The successfully fabricated Si nanowire cantilever (width: 150nm, length: 50 µm) with nickel pattern is shown in Fig. 1. The resonance frequency of the Si nanowire cantilever is measured by laser Doppler vibrometer in vacuum (< 10^{-2} Pa) as shown in Fig. 2. The resonance frequency of the Si nanowire cantilever is 8.006 kHz with 5000 of Q factor (Fig. 3). At the room temperature, the minimum detectable force of the SiNW-cantilever is calculated to be 1.9 x 10^{-16} N. The Si nanowire cantilever with nickel magnet has been successfully fabricated with top-down fabrication process. We believe that this development will provide a molecular imaging by MRFM.

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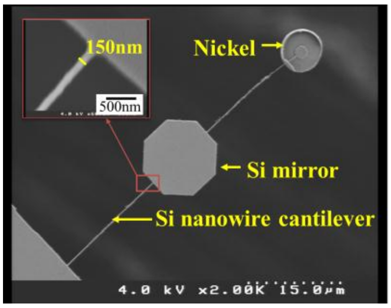

Fig. 1. SEM image of SiNW-cantilever with a nickel magnet.

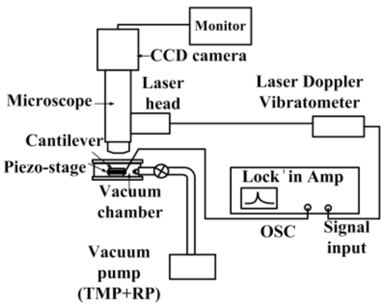

Fig. 2. Schematic of the measurement setup.

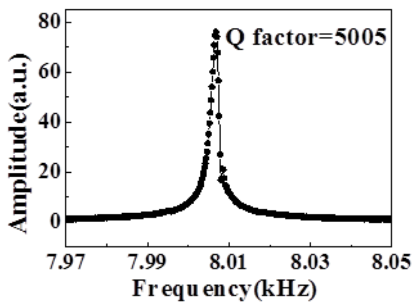

Fig. 3. Mechanical resonant spectrum of the nanowire probe.