A CMOS Amplitude Detector for High-speed AFM Designs

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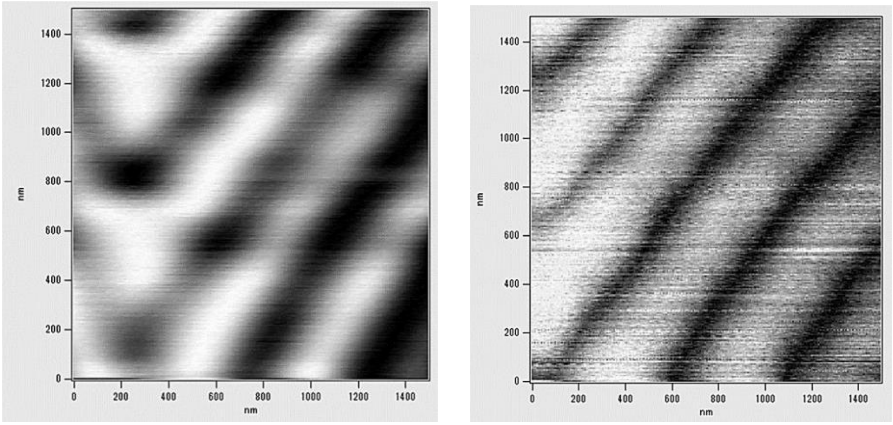
Abstract

Atomic force microscopy (AFM) has become the most important tool for characterizing the structures and mechanical properties of material surfaces on the scale of nanometers. It allows high-resolution imaging of biological samples in physiological solutions. However, it usually takes minutes to take an image with AFM. The functions of biological systems are produced through dynamic processes, which are too fast for AFM. We developed a high-speed AFM by speeding up the amplitude detection which takes the most time in the prototype system. We proposed an amplitude detector implemented with discrete components detects an amplitude with one input cycle. The latency is about 840ns as the input with 1.5MHz in measurement. And the circuit works on our AFM prototype successfully with the clearer image than Zurich Instrument H2FLI. In addition, we implement the circuit in UMC 180nm CMOS process, and the integrated circuit detects an amplitude with half input cycle. The latency is about 500ns and the nonlinear error is 1.56×10^{-5} smaller than 2^{-12}. The circuit achieves 10-bit resolution and consumes 0.93mW power dissipation in our post-layout simulation.

Keywords: AFM, high-speed AFM, amplitude detector, CMOS integrated circuits



(a) (b)

Fig. 1: Scanning result of (a) Zurich Instrument H2FLI (b) proposed circuit.