Frequency Modulation Feedback Control for Near-Field Acoustic Characterization of Mesoscopic Fluid Films

Devulapalli, Pramith

The enigmatic properties of the mesoscopic fluid confined between two solid objects or adsorbed on a substrate have puzzled scientists in the field of condensed matter. One of the current methods to describe mesoscopic fluids is Shear Force Acoustic Near-Field Microscopy (SANM). SANM consists of a fabricated probe attached to a quartz tuning fork that vibrates at resonance. With the substrate and the probe as two solid boundaries, the dynamics of the liquid are recorded from the changes in the tuning fork's amplitude and the ultrasonic signals generated by the probe's mechanical motion. The shrinking amplitude of the tuning fork can be attributed to multiple variables and this is the central deficiency in SANM. The addition of frequency modulation to match the driving frequency to the local resonance frequency is used to improve the instrumentation of SANM. Frequency modulation consists of three phases: Lock-In Amplifier, Proportional Integral Differentiator Microcontroller (PID), and Voltage Controlled Oscillator (VCO). The Lock-In Amplifier is used to detect the phase shift of the output signal of the tuning fork. That phase shift runs to the PID and calculates an error against a set point of ninety degrees. The calculated error causes the VCO to drive the tuning fork at the local resonance frequency. As this cycle continuously repeats, resonance of the tuning fork is guaranteed. Current results prove the claim of successful implementation of a Lock-In Amplifier, PID, and VCO. Future research of research of frequency modulation is to characterize the mesoscopic fluid films.

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