Low temperature internal friction study of loss mechanisms of mechanical oscillators

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In order to understand the loss mechanism of mechanical oscillators in micro-electromechanical systems (MEMS), we have studied the low temperature internal friction of a high Q single crystalline silicon mechanical oscillator (Q^{-1}=2_10^{-8} at below 10 K). Seven modes with principally out-of-plane motion have been identified, and their mode shapes studied by both laser-Doppler vibrometry measurements and simulations of 3-dimensional finite element Method (FEM) [1]. At temperatures above 70 K, the energy loss is principally caused by thermoelastic effect in the flexural components of the modes. Below 50 K, we find the internal friction for all seven modes become temperature independent. The internal friction is also found to be insensitive to the mounting of the oscillator and its environment, and improvements in vibration isolations guided by the FEM. This indicates that some intrinsic loss mechanism may still be important even at low temperatures.

[1] Xiao Liu, S. F. Morse, J. F. Vignola, D. M. Photiadis, A. Sarkissian, M. H. Marcus, B. H. Houston, Appl. Phys. Lett. 78, 1346 (2001)