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Nanomechanical detection of nuclear magnetic resonance using a silicon nanowire oscillator

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"Bottom-up" nanomechanical devices such as nanowires, nanotubes, and grapheme oscillators have previously been proposed as next-generation scanning probe force and mass sensors because of their potential for ultralow mechanical dissipation. Here, we report the use of a radio frequency silicon nanowire mechanical oscillator as a nuclear magnetic resonance force sensor to detect the statistical polarization of ^{1}H spins in polystyrene. Using a specialized scanning probe microscope, as well as a polarization-enhanced fiber-optic interferometer, we operate the nanowire as a force sensor at cryogenic temperatures. Nanowires of the type we study have very low intrinsic dissipation, and they experience negligible increase in dissipation as close as 10 nm from a surface. In order to couple the ^{1}H spins to the nanowire oscillator, we have developed a magnetic resonance force detection protocol which utilizes a nanoscale current-carrying wire to produce large time-dependent magnetic field gradients as well as the rf magnetic field. Under operating conditions, the nanowire exhibited an ultralow force noise of 1.9 aN^2/Hz in the measurement quadrature. Further progress toward nanometer scale magnetic resonance imaging using this technique is discussed.