Microfabricated Force-Detected Nuclear Magnetic Resonance Spectrometer

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NMR Spectroscopy is the premier spectroscopic method used for identification of chemical compounds. A miniaturized portable NMR spectrometer is highly desirable for field investigation of materials and in-situ planetary exploration. We are developing a novel microfabricated force-detected nuclear magnetic resonance (FDNMR) spectrometer with predicted sensitivity superior to conventional NMR at micron scales. This higher sensitivity arises from the signal-to-noise ratio scaling as $d^{0.5}$ for the force detection technique, and as d^2 for conventional NMR (d: sample diameter). Other force detection approaches suffer from broadening of the NMR lines and losses in sensitivity due to the magnetic field gradient imposed on the sample. We overcome this problem by producing a homogenous magnetic field across the sample using a symmetric magnet assembly. Our FDNMR detector consists of a harmonic oscillator comprised of a detector magnet mounted on a microfabricated Si beam. The detector magnet sits within an annular magnet and thus provides a uniform magnetic field over the entire sample volume. Rf pulses applied to the sample modulate the dipole-dipole interaction between the nuclear magnetic moment of the sample and the detector magnet at the mechanical resonance frequency of the oscillator. We detect the resulting motion of the mechanical oscillator at the Brownian-motion limit using a fiber-optic interferometer. Proton NMR spectra of H_2O and CH_2FCN have been obtained with our mm-scale prototype FDNMR device, and development of the microfabricated FDNMR is underway.