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Chip-based Magnetic Resonance System for Medical Diagnosis
HAKHO LEE, TAE-JONG YOON, RALPH WEISSLEDER, Massachusetts General Hospital/Harvard Medical School — We have developed a chip-based, diagnostic magnetic resonance (DMR) system that can perform rapid, quantitative and multi-channeled detection of biological targets. The measurement is based on the effect of molecularly targeted magnetic nanoparticles on NMR (nuclear magnetic resonance) signals. With magnetic nanoparticles bound to their intended detection targets, the overall spin-spin relaxation time of bulk samples will be significantly shortened, as the particles efficiently dephase spins of surrounding water protons. Because the signal detection relies on NMR, the interference from media becomes negligible, making it possible to perform measurements in native biological samples (e.g., blood, sputum and urine). As proof of concept, we have developed a first DMR prototype by integrating microcoils, microfluidic channels and a permanent magnet. The microcoils, used as an NMR probe, are arranged in an array format for multiplexed, parallel detection. The microfluidic channels provide on-chip mixing between magnetic nanoparticles and biological samples and confine the mixture to microcoils for high filling factor. Here, we demonstrate clinical utility of the DMR system by measuring proteins at exquisite sensitivities ($\sim$1 pM), identifying the disease condition of human sera, and profiling cancer cells according to their cell-surface markers.

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