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High-speed transport and magneto-mechanical resonant sensing of superparamagnetic microbeads using magnetic domain walls[1]

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Surface-functionalized superparamagnetic (SPM) microbeads are of great interest in biomedical research and diagnostic device engineering for tagging, manipulating, and detecting chemical and biological species in a fluid environment [1-5]. Recent work has shown that magnetic domain walls (DWs) can be used to shuttle individual SPM microbeads and magnetically tagged entities across the surface of a chip [1-5]. This talk will describe the dynamics of SPM microbead transport by nanotrack-guided DWs, and show how these coupled dynamics can be exploited for on-chip digital biosensing applications. Using curvilinear magnetic nanotracks, we demonstrate rapid transport of SPM microbeads at speeds approaching 1000 μm/s [3], and present a mechanism for selective transport at a junction that allows for the design of complex bead routing networks. We further demonstrate that a SPM bead trapped by a DW exhibits a distinct magneto-mechanical resonance that depends on its hydrodynamic characteristics in the host fluid [4, 5], and that this resonance can be used for robust size-based discrimination of commercial microbead populations. By embedding a spin-valve sensor within a DW transport conduit, we show that the resonance can be detected electrically and on-the-fly [5]. Thus, we demonstrate a complete set of essential bead handling functions, including capture, transport, identification, and release, required for an integrated lab-on-a-chip platform.

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