An On-chip Micromagnet Frictionometer Based on Magnetically Driven Colloids for Nano-Bio Interfaces

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A novel method based on remotely controlled magnetic forces of bio-functionalized superparamagnetic colloids using micromagnet arrays was devised to measure frictional force at the sub-picoNewton (pN) scale for bio-nano-/micro-electromechanical system (bio-NEMS/MEMS) interfaces in liquid. The circumferential motion of the colloids with phase-locked angles around the periphery of the micromagnets under an in-plane rotating magnetic field was governed by a balance between tangential magnetic force and drag force, which consists of viscous and frictional forces. A model correlating the phase-locked angles of the steady colloid rotation was formulated and validated by measuring the angles under controlled magnetic forces. Hence, the frictional forces on the streptavidin/Teflon interface between the colloids and the micromagnet arrays were obtained using the magnetic forces at the phase-locked angles. The friction coefficient for the streptavidin/Teflon interface was estimated to be approximately 0.036 regardless of both vertical force in the range of a few hundred pN and velocity in the range of a few tenths of μm s-1.