Supporting information for

Magneto-Optical Biosensing Platform based on Light Scattering from Self-Assembled Chains of Functionalized Rotating Magnetic Beads

Materials

We used commercially available biotinylated supermagnetic beads (SBs) with an inner core composed of nanometer-sized magnetite particles and were covered with biotins of 1 x 10^6 groups/bead. The average diameter of the SBs (a) was 244 ± 48 nm as determined by a zeta-potential meter. The magnetic susceptibility (χ) of the beads was 1.35 in the linear region. Biotinylated SBs suspension with 19.85 pM (volume fraction = 9.77 x 10^{-4} %) was diluted with a phosphate buffer solution (PBS: pH = 7.0) (product no. 37242-55, Nacarai tesque Inc., Japan)

The avidin solution was prepared using 5mg of avidin powder (product no. 04553-64, Nacarai tesque Inc., Japan) and dissolving it into 10 mL of PBS.

Experimental set-up

Magneto-optical transmittance experiments

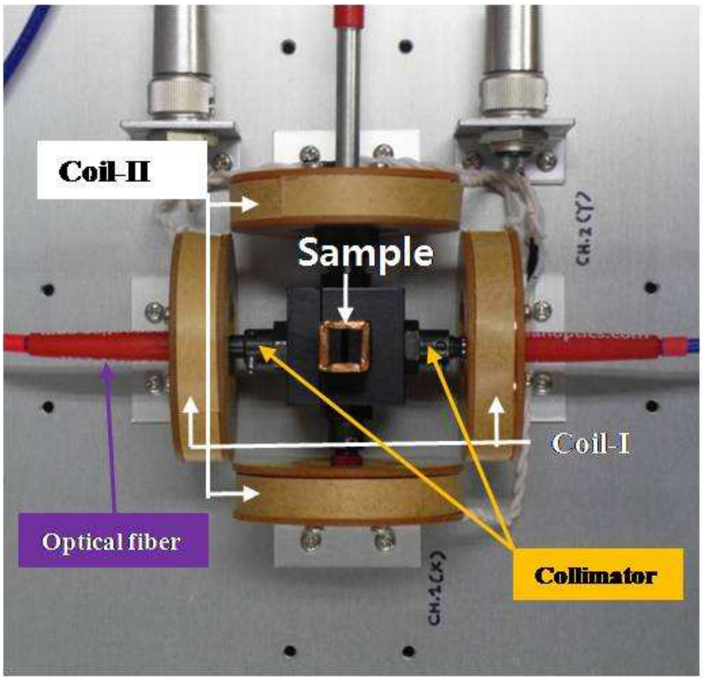

Figure S1. Photograph of magneto-optical transmittance experimental setup

Rotating fields were generated by a coupled pair of ac coils in which the phase of the magnetic field between Coil-I and Coil-II was kept at $\pi/2$. The frequency (f) of the sinusoidal excitation current and the field strength (H) were controlled by a two channel function generator (WF1974, NF Co., Japan) which was connected to a two channel power supply. The strength of the rotating magnetic field was measured by a Hall probe (Lakeshore, USA). Light source used in this study was a tungsten halogen bulb (LS-1, OceanOptics, USA), which was guided by an optical fiber, and collimated using collimating lens (74-VIS, OceanOptics, USA). The transmitted light was detected using a spectrometer (USB 4000, OceanOptics, USA). The integration time of spectrometer was kept constant at 20 msec.

Microscopic image of SBCs

The structure and motion of a biotinylated SB solution in a disposable micro-cuvette of 50 uL (CFV-PIP-SP, OceanOptics, USA) were observed under rotatable Helmholtz coil using a CCD microscope camera, where digital images of 512 x 480 pixels were magnified by 2000 times. At this magnification, one pixel size was equivalent to 0.45 x 0.45 μm^2. Therefore, it was difficult to unambiguously identify isolated and doublet beads. The images were processed by Photoshop software to enhance their contrast and an image analysis program was used to determine the size distribution of SBC.

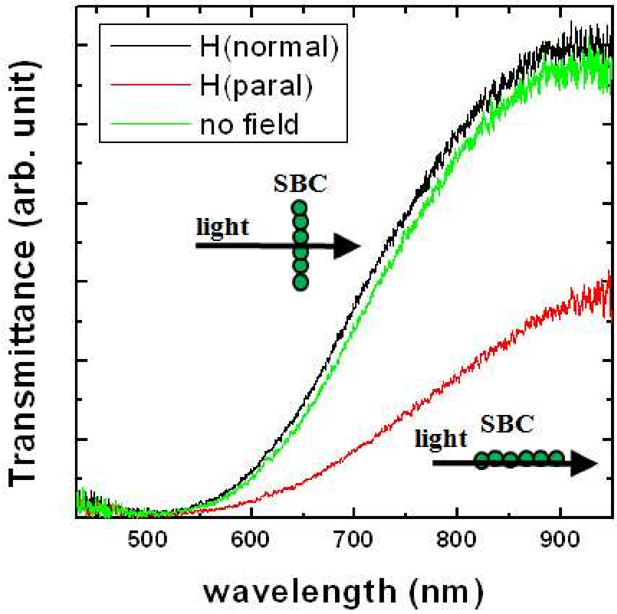

Figure S2. Optical transmittance spectrum of a SBC solution under different magnetic field configurations: θ=0 (red), π/2 (black), and in absence of magnetic field (green) .

In order to determine optimal wavelength for maximizing the signal-to-noise ratio and MT ratio, the optical transmittance spectra of SBC solutions under two different magnetic fields $\theta = 0$ (red line), $\pi/2$ (black line) and without the field (green line) were taken. We observed continuous spectra without any peaks in measurable range. All the transmitted light below $\lambda \approx 540$ nm underwent the largest scattering, resulting in opacity, meanwhile the optic al transmittances were drastically increased with increasing λ. The MT ratio and signal-to-noise ratio in the wavelength range of 700 nm to 800 nm exhibited the optimal value.

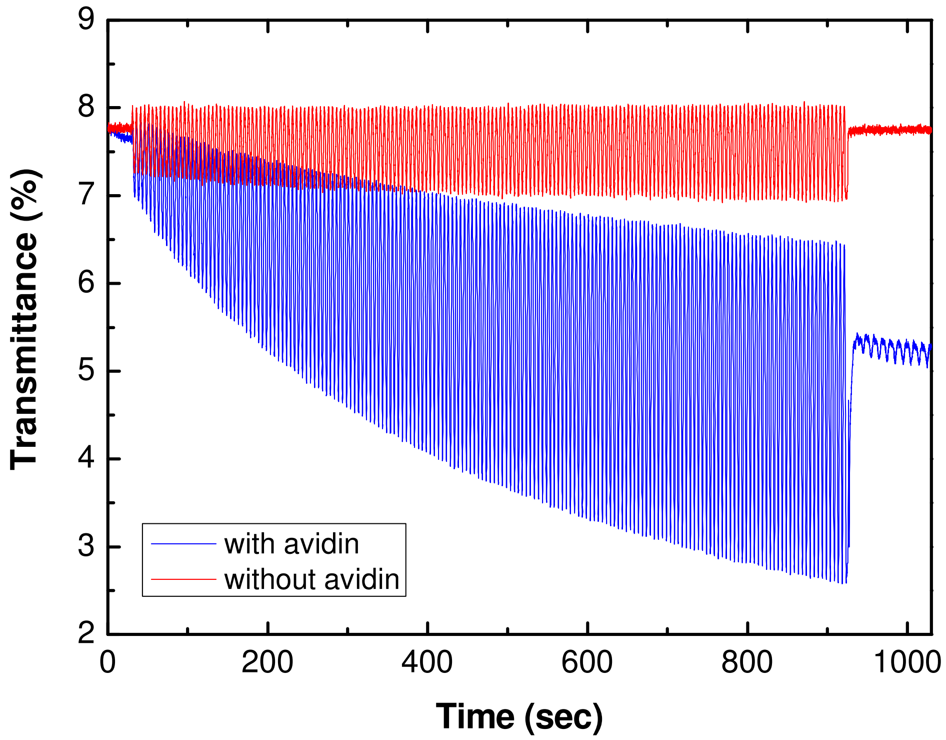

Figure S3. Optical transmittance of SBC solutions without avidin (red) and with avidin (67.8 nM) at $f = 0.1$ Hz.

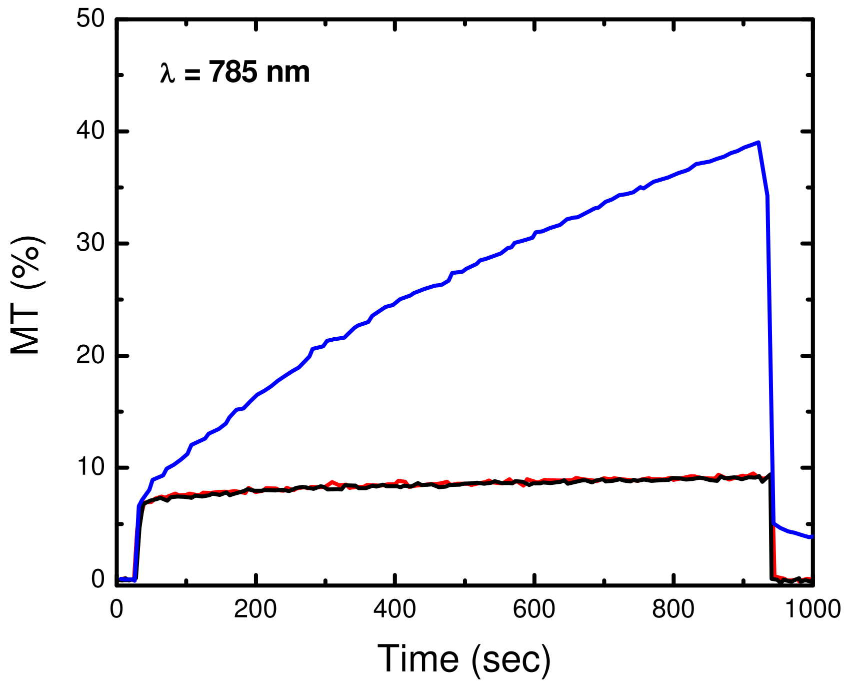

Figure S4. The time dependence of MT ratio of biotinylated SBC solutions (red), adding 0.1 mM of BSA in biotinylated SBC solution (black), and adding avidin in biotinylated SBC-BSA solution (blue).

f (Hz)	ΔMT_0 (%)	ΔMT_i (%)	τ_i (sec)	ΔMT_f (%)	τ_f (sec)
0.05	0.29	1.29	117.72	4.03E+14	2.80E+17
0.1	0.43	1.23	64.26	2.26E+14	1.49E+17
0.5	2.78	3.38	16.3	2.05E+14	1.30E+17
1	1.77	3.393	15.74	2.16E+14	1.27E+17

Table S1. Fitting parameter used in Eq. (2)