Polarization Properties of a-SNOM

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The aperture less scanning near-field optical microscopy (a-SNOM) is a promising technique to control spins using light in nano-scale, because a near-field light utilized in a-SNOM is enhanced several orders stronger than an incident light and could have a diameter of < 10 nm. However, controlling of polarization of near-field light in a-SNOM is the most important issue to be solved. In order to control the polarization of the light in the a-SNOM, we need to understand polarization properties of a-SNOM first.

The a-SNOM developed in this study is based on a commercial scanning probe microscope (SPI3800N probe station and SPA300 unit, Seiko Instrument Inc.)[1]. A cantilever (SI-DF3P2, SII NanoTechnology Inc.) made of silicon having an extremity's radius of 7 nm with a resonant frequency Ω of ~ 80 kHz is used. A laser diode (TC20-4030-4.5/15, Neoark corp.) with a wavelength of 408 nm is used as a light source. The laser beam is focused on the top of the probe by using a plate-type lens with an incident angle of 45 degrees. A scattered light from the sample's surface in the near-field close to the tip apex is measured by a photomultiplier tube placed after the beam splitter. Signals were measured by the lock-in detection method for reference frequencies of Ω and 2Ω. Polarization properties were measured by using a set of polarizers. FDTD simulation was carried out to analyze distribution and polarization of lights around probes.

Figure 1(a) shows intensities measured for a Cr film plotted as a function of the angle of the analyzer θ_a, where the azimuth angle of the incident light, θ_i, is 40 degrees. We found that the shape is like a four-leaves clover, while a linearly polarized light gives a curve expressed by $\cos^2\theta$. We have decomposed the result by assuming that it is a superposition of signals from the top of the probe and the background as shown in Fig.1(b), where the background signals were calculated as an intensity of light reflected by a probe and a Cr film. Consequently, we obtained azimuth angles of SNOM signals for each θ_i as shown in Fig.2. A result of FDTD simulation is also plotted in Fig.2, which agrees well with the measured data. We also find that the a-SNOM act as wave plate expressed by Jones matrix, indicating that the polarization property of the a-SNOM is maintained.

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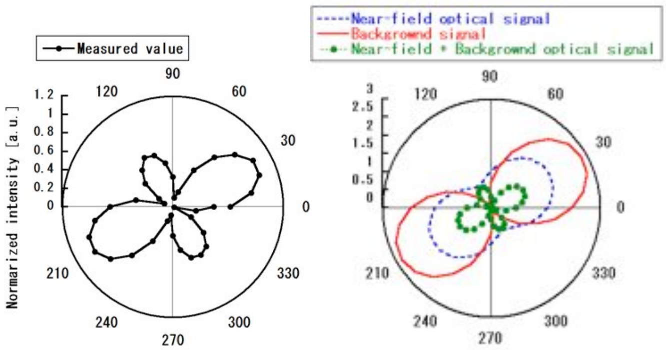

Fig.1 (a) Intensities measured for a Cr film with θ_i = 40º, plotted as a function of θ_a, (b) a result of fitting.

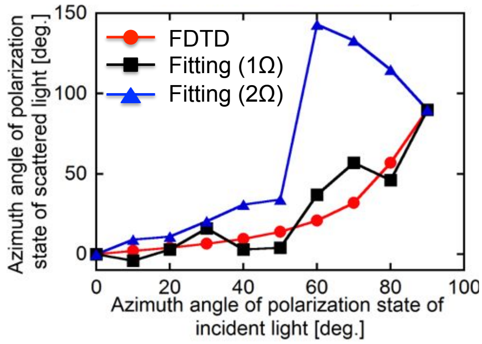

Fig.2 Azimuth angles of SNOM signals for each θ_i.

Reference

1) M. Aoyagi , S. Niratisairak , T. Sioda , and T. Ishibashi, IEEE Trans. Magn. **48**, (2012) 3670.