Simultaneous electrical and optical detections of spin-torque ferromagnetic resonance

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Spin-torque ferromagnetic resonance (ST-FMR) by means of an electrical homodyne detection has widely been used to study the magnetic properties and spin-torque efficiency. By exerting an oscillating spin-torque (*e.g.* spin-transfer-torque [1], spin-orbit-torque [2], and voltage-torque [3]) on the magnetic moment at the resonance conditions, a rectified dc voltage is generated as a result of mixing between the microwave current and resentence oscillation. In this study, we performed the ST-FMR measurement in Pt/Py bilayer structures with the electrical homodyne detection and optical heterodyne detection simultaneously, and investigated the spatial-resolved spin precession dynamics in ST-FMR measurement.

We prepared Py(5 nm) / Pt(6 nm) films grown on a thermally oxidized Si substrate by magnetron sputtering. The film was patterned into a 5-μm-wide strip with a coplanar waveguide. Figure 1(a) shows the device and the measurement setup used in this study. In addition to the optical heterodyne detection path reported in our previous studies [4], the electrical homodyne detection path was incorporated. The electrical signal from the rectified voltage V_{dc} and the optical signal from the magneto-optical Kerr effect in the polar configuration S_{21} were recorded by sweeping the external magnetic field with fixed microwave frequency. Figures 1(b)(c) show the simultaneously measured FMR spectra at various microwave frequencies. From the line-shape analysis, we found slightly different line-widths between electrical and optical signals. From the spatial-resolved FMR measurements in the optical signal, we also found that the inhomogeneous broadening and the Gilbert damping constant depend on the position in the width direction. In the presentation, we will discuss more details for the spatial distributions of the magnetic properties.

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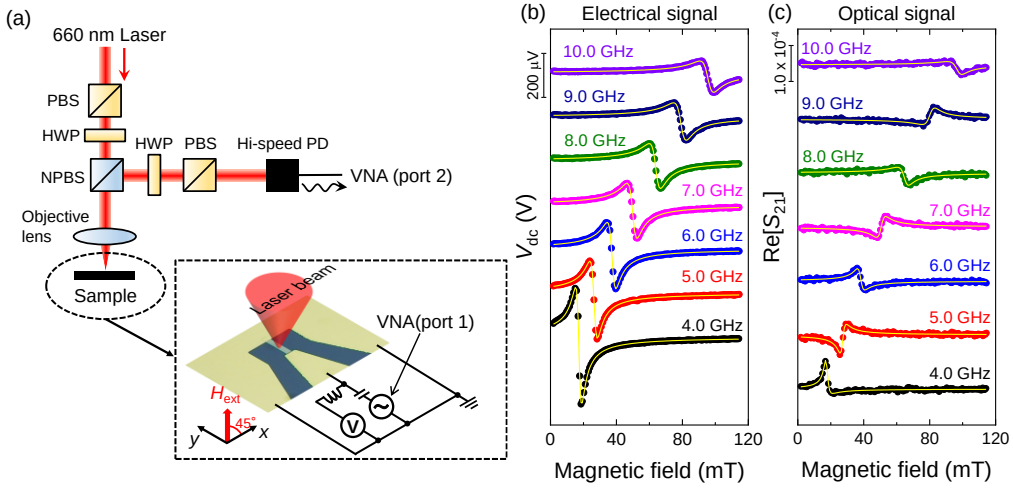

Fig. 1 (a) Measurement setup (b)(c) Electrical and optical signals of ST-FMR spectra.