SIMULTANEOUS ACQUISITION OF MAGNETIC DOMAIN STRUCTURE AND LOCAL MAGNETIZATION CHARACTERISTICS DURING FIELD SWEEPING

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I. INTRODUCTION

Studies and developments of spintronics devices such as STT-MRAM are continuously expanding. Investigation of relationship between magnetic domain structure and local magnetization characteristics is essential because magnetic behaviors of local magnetization characteristics significantly influence device's performance. Magneto-optical Kerr effect (MOKE) based microscope is a well-known apparatus to study magnetization behaviors. In most MOKE microscopes, magnetic domain images are obtained by using imaging camera within its field of view at once. Furthermore, magnetization curves can be calculated from brightness in values of few pixels from observed images [1]. However, obtaining low noise magnetization curves by this method contains considerable difficulties due to the limitation of optical detection performance of the imaging camera. In this study, we report a successful development of a high contrast magnetic domain microscope equipped with low noise magnetization curves measurement system by using focused LASER.

II. RESULTS

Fig.1 shows a schematic of the optics for magnetic domain observation. Köhler illumination was used in optical system for magnetic domain observation, and a light beam was designed to focus to objective lens' back focus. Fig.2 shows a schematic of additional optical system for measuring magnetization curves. The LASER, wavelength 650nm, was adopted as a light source, and its beam was focused to a surface of a magnetic sample. The equipment was integrated with two types of optical systems in one package. For low noise magnetization curves measurement, superimposing an RF signal of 500 MHz on driving current of the LASER was carried out aiming for both speckle noise reduction due to decreasing of coherency [2] and Magneto Optical (MO) signal modulation. A lock-in technique was applied to demodulate the low noise MO signal. A compact balanced detector with Gran-Thompson prism (GTP) was developed as a light receiving device. “p wave” and “s wave” of incident LASER were separated by GTP and were converted from optical signal to electric signal. Measurement sensitivity was much improved by a processing of difference between both signals. The differentiated signal was input to a lock-in amplifier. A lock-in technique was applied to demodulate low noise MO signal. Output signal from lock-in amplifier is inputted to AD converter of computer. Bit resolution of AD converter for computer is higher than bit resolution of general industrial camera. It is one of advantage for magnetization curves measurement with the LASER.

Fig. 3 shows a typical comparison between magnetization curves obtained by brightness of pixels in a domain image and modulated LASER for a thin film. Less noise was observed in the magnetization curves measured by LASER compared with that by brightness. Figs. 4 show (a) magnetic domain image under zero magnetic field and (b)-(c) local magnetization curves in μm area for a NiFe patterned thin film. The pattern showed multi-domain state mainly caused by shape anisotropy. According to the local magnetization curves, different wall-motion and rotational magnetization processes are clearly observed due to low noise MO signal.

In conclusion, low noise magnetization curves combined with changes in domain structure revealed detailed information of magnetization in μm area.

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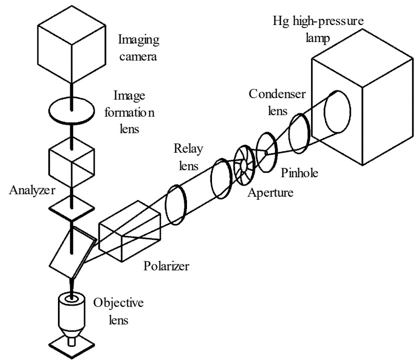

Fig. 1 Schematic of the domain observation microscope.

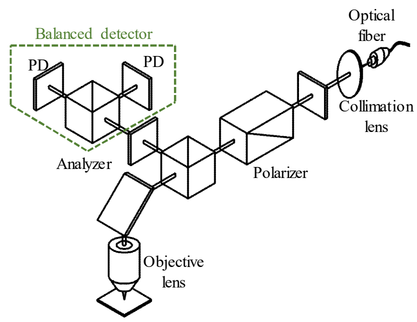

Fig. 2 Schematic of the additional optics for measuring magnetization curves.

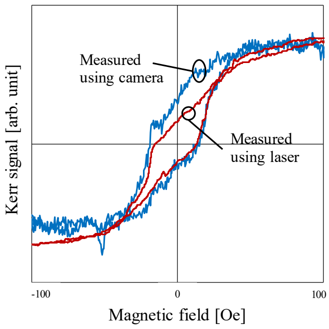

Fig. 3 Comparison of magnetization curves.

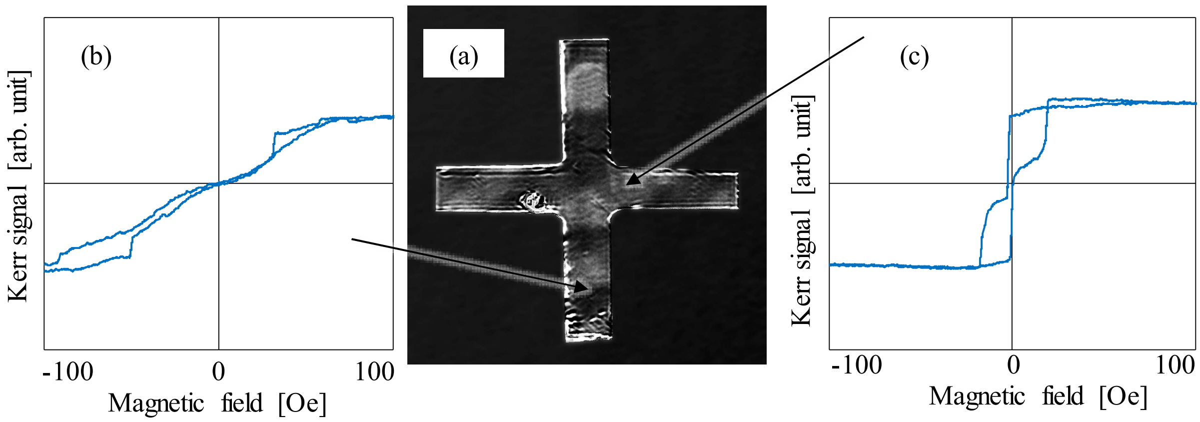

Fig. 4 Magnetic domain image and magnetization curves of the NiFe patterned thin film.

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