Magnetic domain imaging of Ni micro-dot array by photoelectron emission microscope (PEEM)

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Introduction

The magnetic properties of the small size magnetic elements are recently extensively investigated for the point of view of technological applications, such as high density magnetic storage[1]. It is important to examine the influence of the stray field from neighboring magnetic dots of magnetic dot array when the density of the magnetic dots becomes extremely high. In this paper we report the direct magnetic domain observation of such magnetic dot array of Ni by photoelectron emission microscope(PEEM) with using x-ray magnetic circular dichroism (XMCD) technique in order to examine the interaction between neighboring magnetic dots in the magnetic dot array.

Experimental

Circular, square, hexagonal and triangular shaped Ni micro-dot arrays with the dot size of 10 μm were fabricated on the silicon wafer using electron beam lithography and lift-off techniques. The thickness of the Ni dots were 40 nm. The separation between each dot is 100 nm for the case of the square, hexagonal, and triangular shaped dots.

All the domain imaging of the dot arrays by XMCD-PEEM was performed at room temperature. The circularly polarized soft x-ray light from the off-axis of the bending magnet radiation was injected to the sample at about 18 degree from the sample surface. The magnetic domain images were obtained by dividing the photoelectron images taken at the Ni L_3-edge (hν=877.2 eV) by those of at the L_2-edge (hν=852.7 eV).

Results and discussion

Figure 1(a) shows the magnetic domain images of the portion of the Ni micro-dot array with circular shaped micro-dots of 10 μm. In the figure the circularly polarized soft x-rays were illuminated from downward to upward. Therefore bright and dark regions in the image correspond to magnetic domains positively and negatively magnetized along the direction parallel to the light axis. As shown in the figure many magnetic dots have a magnetic domain contrast with bright and dark part in the right(left) and left(right) half side of the dot. These domain contrasts indicate that the magnetic domain structure is so called flux closure type[1]. Each micro-dot, however, shows an individual domain structure and it seems to have no relation between neighboring dots. In contrast with the circular shaped dot arrays, the magnetic domain structure of the square (Fig. 1.(b)), hexagonal (Fig. 1(c)), and triangular (Fig. 1(d)) shaped dot arrays seems to have some relation between neighboring dots. That is, the domain structure looks like the magnetic domain structure of continuing Ni sheet and the boundary of the square or hexagonal or triangular dots is not clear. This difference of the magnetic domain structure between circular and other shaped Ni dots may be caused by the difference of the stray field of the dots. Since the circular shaped dot tends to have a flux closure type domain structure, the stray field should be weak and the influence from a neighboring dot is small. In addition, circular shaped dots which are touched by point with neighboring dots, contrast to the other shaped dots which are touched by line, may reduce the influence of the stray field of neighboring magnetic dots.

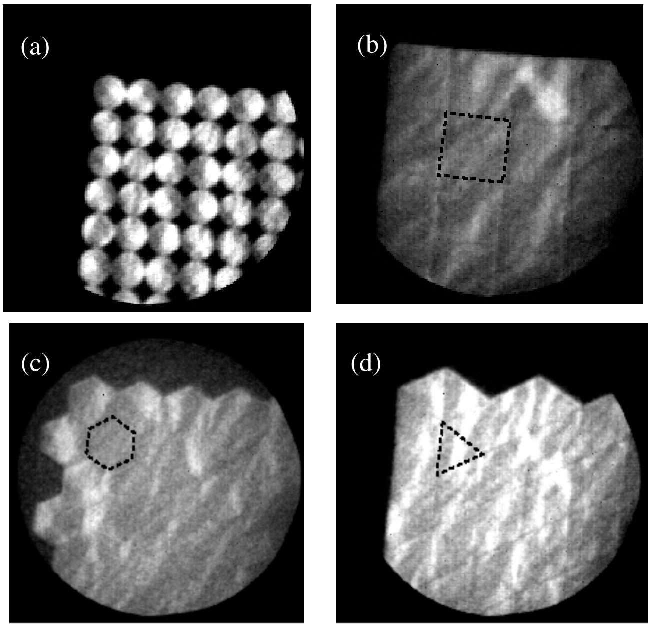

Fig.1 (a) Magnetic domain images of the circular shaped Ni micro-dot arrays with the size of 10 μm. (b) The same as (a) but with the square shaped dots. (c) The same as (a) but with the hexagonal shaped dots. (d) The same as (a) but with the triangular shaped dots. The unit of square, hexagonal and triangular shaped dots are indicated for the eyes.

References

[1] S.P. Li et al., Phys. Rev. Lett. 86, 1102 (2001) and references there in.

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