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Micropatterned high permeability films with narrow bandwidth resonance loss for the band stop filter

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In this work the micropatterned CoNbZr films designed for the band stop filter are reported. It was already reported that a 400-μm-wide coplanar line equipped with a 4-mm-wide CoNbZr film exhibits band stop characteristics, but practically the width of the film must be about the same size as the signal line. This limited width of the micropattern gives rise to dispersion of the shape anisotropy, resulting in degradation of band stop characteristics. Here we fabricated 150-μm-wide patterned films with adjusted edge dimensions which widths have been enlarged from 20 to 40 μm that were optimized on the permeability database. The resonance loss profile for the adjusted pattern is compared with that of a film without adjusted edges. The half width is appreciably decreased from 2.2 to 0.77 GHz. In conclusion an improvement of the resonance profile of micropatterned films was achieved by optimizing the edge dimensions. This will enable us to utilize magnetic films for more downsized signal lines. © *2006 American Institute of Physics*. [DOI: 10.1063/1.2171950]

I. INTRODUCTION

Recently a band stop filter using ferromagnetic films has been investigated.[1] Their characteristics are improved by narrowing the resonance loss profile by applying a dc field. On the other hand, we have reported band stop characteristics using micropatterned ferromagnetic CoZrNb film.[2] The ferromagnetic resonance frequency is controlled by the pattern shape, therefore an external dc field is not required. The effective anisotropy field of micropatterned films depends on the shape anisotropy of each rectangular film and the magnetostatic interaction between neighboring films. The most of rectangular films have two neighboring films in both side, however, the rectangular film on the edge has a single neighbor. This structural difference causes dispersion of the anisotropy because of an increase of an anisotropy field on the edge. In the case of a band stop filter for narrow transmission lines, relatively large dispersion is unavoidable because the total number of rectangles is limited and the effect of an edge part is not negligible. We focus attention on the edge design of the film and optimize the edge part to reduce dispersion of the anisotropy appreciably.

II. DESIGN OF PATTERN SHAPE

The pattern shape is designed for 0.5-μm-thick CoZrNb film which saturation magnetization is 10 kG and intrinsic anisotropy field is 10 Oe. The permeability database[3] for the micropatterned film and Osborn's equation[4] for demagnetizing factor of ellipsoids are used for the estimation of effective permeability of micropatterned films and different pattern dimensions. We assumed that the edge film has half of the effective permeability of other films because the edge film has half of the magnetostatic interaction with neighboring films. A small dispersion of the shape anisotropy is required to get a sharp resonance loss peak, then the width of edge film is enlarged than others for same effective permeability. When 20/2.5 μm (linewidth/slit width) and the total number of rectangle is limited to 5, the optimum width of edge film was estimated to be 40 μm when the total width of whole of patterned film is 150 μm.

III. SAMPLE PREPARATION

The samples were composed of sputtered 0.25-μm-thick CoNbZr magnetic film, 10-nm-thick intermediate Nb, and 0.25-μm-thick CoNbZr magnetic film on a glass substrate (see Fig. 1). The pattern was fabricated by ion milling method. The basic pattern dimension is 20/2.5 μm (linewidth/slit width) and the widths of edge rectangles are 20, 30, 40, and 50 μm. The samples were annealed twice in a dc field at 400 °C to reduce their anisotropy dispersion, once after deposition and once after patterning. Figure 2 shows photos of the samples, the sample shown in the left has 20 μm width edges and the sample shown in the right has 40 μm width edges.

IV. COMPLEX PERMEABILITY

The frequency characteristics of complex permeability was measured with a permeameter.[5] In Fig. 3, the resonance

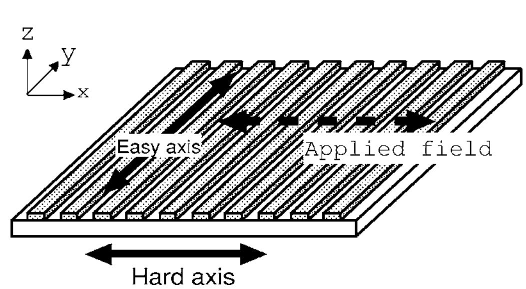

FIG. 1. Schematic view of micropatterned magnetic film.

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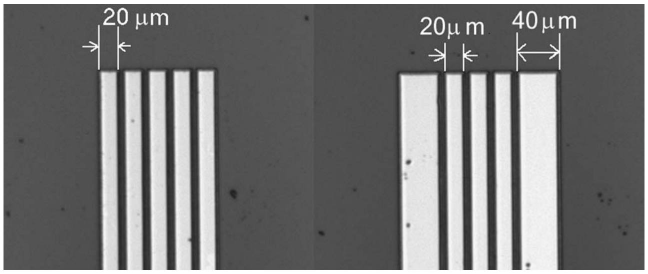

FIG. 2. Photograph of patterned films. The sample in the left has 20 μm width and 2.5 μm gap homogeneous edges, while the sample in the right has 40 μm width edges.

loss profile for the adjusted edge pattern is compared with that of a film without adjusted edges. The half width is appreciably decreased from 2.2 to 0.77 GHz. Figure 4 shows the edge width dependence of resonance frequency and the half width of resonance loss. The resonance frequency is decreased by enlarging the edge width from 20 to 40 μm, this means that the anisotropy of the edge elements is larger than these of the other parts in this dimension range.

V. CONCLUSION

An improvement of the resonance profile of micropatterned films was achieved by optimizing the edge dimensions. The half width of resonance loss is appreciably decreased from 2.2 to 0.77 GHz when the width of the edge is enlarged from 20 to 40 μm for the fixed total width of 150 μm. In conclusion, large anisotropy of the edge part of micropatterned films causes the increase of anisotropy dispersion, however, it is possible to give a solution by the edge pattern. This will enable us to utilize magnetic films for more downsized signal lines.

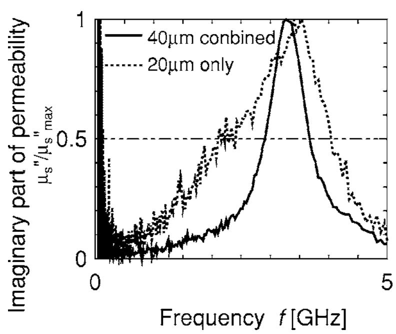

FIG. 3. Measured frequency characteristics of normalized resonance loss.

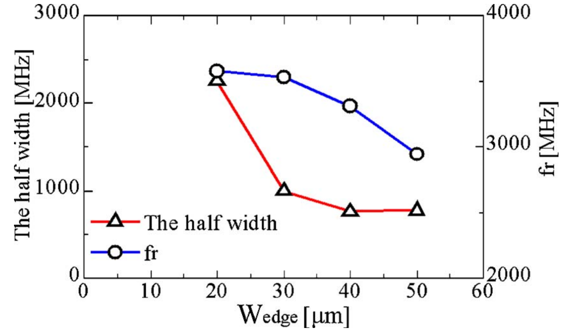

FIG. 4. (Color online) The half width of resonance loss peak and resonance frequency of samples have different edge widths.

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