課題番号　:F-14-NU-0028
利用形態　:機器利用
Program Title (English)　:Magnetoresistive Magnetic Field Sensor Fabrication
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## 1. 概要(Summary)

Magnetic field sensor used as compass in intelligence phones, tablets, and portable devices becomes more and more important due to the increasing needs of various local-based services. The motivation of this study is to develop 3-axis MR-based magnetometers with compact size and high sensitivity.

## 2. 実験(Experimental)

・Facility used:
Laser lithography, sputter system, magnetic field annealing, spin coater, exposer, AGM, hot plate, alpha-step.

・Experiment:
In the first stage, the focus is placed on processing and basic geometry optimization. For AMR, the optimization includes thin film deposition, thickness, and barber-pole geometry; for GMR, it contains field cooling condition of prepared GMR films, patterned element shape, width, length, gap, etc. Electric and magnetic properties are characterized by measurements of MR and AGM.

## 3. 結果と考察(Results and Discussion)

For AMR, we have prepared Ta/NiFe(Py)/Ta films with three different thickness of Py layer for sensing stripes. The tapered Py stripes were successfully formed by RIE, although slight rounding of the taper-ends appeared as shown in Fig. 1. The precision of exposure needs to be improved. The fabrication of barber-pole structure failed. The exposure and development of the photo resistor seems okay, but the lift-offprocess failed. The removal of metal (Au) filmwith photo resistor underneath ripped off the patterned parts as shown in Fig. 1. This reflects the insufficient adhesion of electrode on substrate. Thinner metal and thicker photoresistor could be helpful. Additionally, multilayered electrode is also an option to enhance the adhesion.

For GMR, the first task is to form a pinning direction of the pinned layer via magnetic field annealing.

After the heat treatment with external field of ~2.5 kOe, the pinning direction is found perpendicular to the field direction. The photo mask needs to be rotated by 90 degree. The patterning of GMR element was done by RIE. The quality of fabricated photo mask is good, but the resolution of the exposure is not sufficient for the 1-μm-wide patterns. No patterns of such dimension were formed. For the 2-μm-wide elements showed in Fig. 2(a), designed shape of sharp ends and the body were distorted. The distortion of 3-μm-wide structures was smaller, but end-rounding was still obvious as shown in Fig. 2(b). It can be conclude that high precision exposure is essential for our element fabrication.

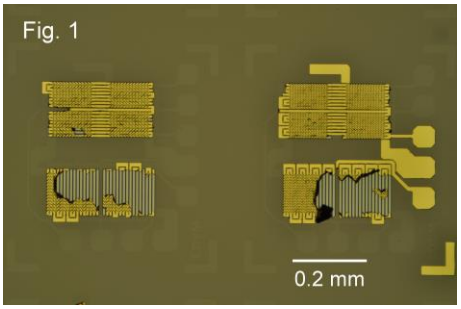


Fig. 1 Failure mode of AMR element.
Left: The removel of pads.
Right: Damage of stripe.

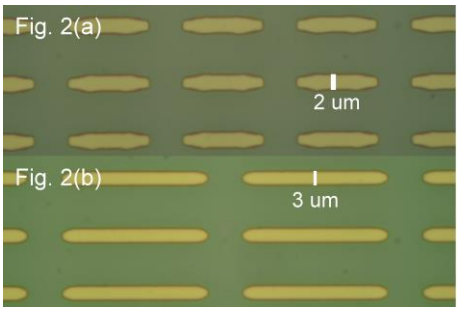


Fig. 2 Shape GMR element.
(a) 2 μm-wide patterns.
(b) 3 μm-wide patterns.

## 4. その他・特記事項(Others)

・We acknowledge Prof. Satoshi Iwata, Prof. Takeshi Kato, and Dr. Daiki Oshima for their great help on micro-processes.

## 5. 論文・学会発表(Publication/Presentation)

None

## 6. 関連特許(Patent)

None