Detecting superficial cracks by using eddy current method and magnetic tunnel junction devices with varied size

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Introduction

The detecting of superficial defects is a critical issue to ensure safety in aerospace and transport industry. The eddy current testing (ECT) is widely applied to evaluate the superficial defects in metals. In ECT, the eddy current generated by using excitation coil, the presence of defect perturbs eddy current distribution so that the induction magnetic field also perturbed. Obviously, in ECT, a magnetic sensor is important for detecting the tiny perturbation of magnetic field. For magnetic sensor, the MTJ device based on tunnel magneto-resistance (TMR) effect have attracted considerable attention due to its large MR ratio and sensitivity [1][2]. Because of the possibility of miniaturization, it is thought that the MTJ device can be applied in high spatial resolution ECT for detecting minute defects. However, few studies attempt to research the effect of single MTJ device size in non-destructive ECT. Therefore, in this study, we investigate the effect of MTJ device size in order to realize the non-destructive ECT with high spatial resolution.

Experimental

The magnetic films were prepared by magnetron sputtering system and their stacking structure was SiO_2-sub./Ta(5)/Ru(10)/Ta(5)/$Ni_{80}Fe_{20}$(70)/Ru(0.9)/$Co_{40}Fe_{40}B_{20}$(3)/MgO(2.5)/$Co_{40}Fe_{40}B_{20}$(3)/Ru(0.9)/$Co_{75}Fe_{25}$(5)/$Ir_{22}Mn_{78}$(10)/Ta(8)(in nm). The MTJ devices with three sizes (20×80μm^2; 60×240μm^2; 120×480μm^2) were fabricated. In order to obtain high linearity, MTJ devices were annealed two times along easy axis of free layer and orthogonal to it at different temperatures. After investigation of the R-H loops of MTJ devices, the eddy current testing was carried out by using automatic ECT equipment with MTJ devices.

Result

As can be seen in Fig.1, the superficial cracks (depth=3mm; width=0.5mm; length=1mm) in Al specimen can be detected by using MTJ devices with varied size. However, for detecting the same cracks, the amplitude of output voltage increases as the MTJ device size decreased. Furthermore, as shown in the two-dimensional images, the non-destructive ECT with high spatial resolution can be realized by using relative small MTJ device due to its large output voltage. Thus, in our work, we found that the non-destructive ECT can be realized by using relative small MTJ device.

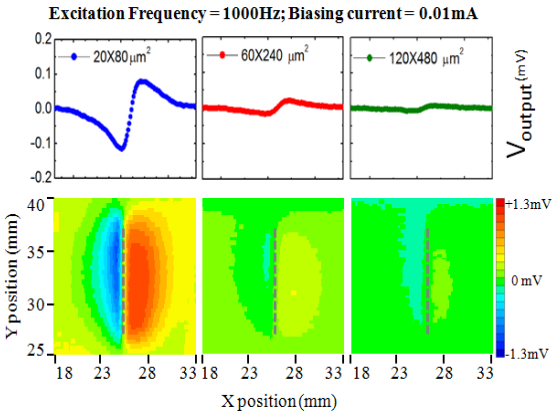

Fig.1.The upper figures show the various output voltages for MTJ devices with various sizes. The bottom figures show the two-dimensional images of ECT, the broken line indicate the position of superficial crack.

Reference

[1] S.Yuasa, *et al.*, Nat. Mater. 3, 868, (2004)
[2] K. Fujiwara, *et al.*, J. Phys. Soc. Jpn. **52**, 04CM07, (2013)