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Sensitivity of SAW Magnetic Sensors composed of various Ni Electrode Structures

様々なＮｉ電極構造を用いたＳＡW磁気センサの感度

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1. Introduction

Authors reported a new type magnetic surface acoustic wave (SAW) sensor composed of only Ni interdigital transducer (IDT) on ST-90°X quartz substrates and its application to a wireless passive SAW sensor system.[1] It is considered that a SAW resonator with a large coupling factor or a high Q enables to realize a sensor with higher sensitivity. A SAW device composed of grooved Cu-electrodes on a $LiNbO_3$ is a larger coupling factor than a conventional structure.[2] On the other hand, a SAW device composed of additional Al electrodes covered on grooved Cu electrodes on a $LiTaO_3$ has a higher Q than a conventional structure.[3] In this paper, the authors try to fabricate SAW magnetic sensors consisting of such various structures using Ni electrode.

2. Various SAW Structure

A leaky SAW (LSAW) on Ni electrode, which is a magnetostrictive material, on an ST-90°X quartz was fabricated as a magnetic sensor.[1] This time, in order to obtain larger coupling factor or high Q, (a)grooved Ni electrodes on the quartz and (b)additional Ni electrodes covered on the (a) structure were fabricated as shown in Figs. 1 to 3. Figures 1 and 2 show their coupling factor on various Ni thicknesses at metallization ratio (MR) of 0.5 and 0.8. Figure 3 shows the reflection coefficient at MR=0.8. A conventional structure (c)Ni electrode on quartz is also shown in Figs. 1 to 3 for reference. Three kinds of structures have the same maximum coupling factor at MR=0.5. On the other hand, both of their coupling factor and reflection coefficient are different as (c) > (b) > (a) structures at MR=0.8.

3. Fabrication of SAW Resonators

The SAW resonators of (a) and (b) structures were fabricated in a process shown in Fig.4; (1) fabrication of resist on the quartz, (2)fabrication of grooves by dry etching, (3)evaporation of Ni electrodes, (4)removing resist. The SAW resonators of 3 kinds of structures have the Ni IDT consisting of wavelength of 14.6μm, 1.5λ of aperture, 40 pairs of IDT, and each grating reflectors with 50 fingers. Their MR is 0.8 because MR=0.8 realized a large magnetic sensivirity.[1] The fabricated (a)structure (No.1) is composed of grooved Ni electrodes of 0.02λ thickness (0/0.02λ) and the (b)structures (No.2 and 3) additional Ni electrodes of thickness 0.01λ and 0.15λ covered on grooved Ni electrodes of thickness 0.01λ and 0.15λ (0.01λ/0.01λ and 0.15λ/0.015λ, respectively). Because the quartz substrate was cracked by the stress of Ni film when the thicker film was deposited than 0.03λ, the SAW resonator with thicker Ni film could not be fabricated. Figure 4 shows a cross section of No.3 measured by SEM. Though the cross section of the thick grooved Cu-electrodes of 0.1λ thickness on the $LiNbO_3$ substrate shows a reverse-trapezoid[2], one shown in Fig.5 shows trapezoid. This cause is that the resist for the off lift shown in Fig.4 was made reverse-trapezoid at dry etching, and the Ni thickness

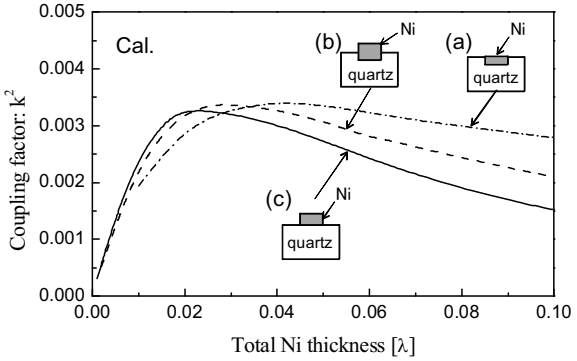

Fig.1 Coupling factor on various Ni electrodes structures/quartz at MR=0.5.

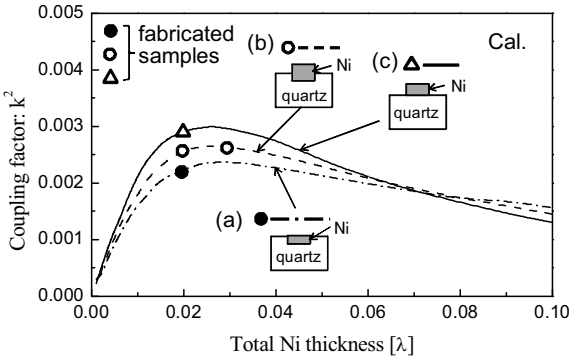

Fig.2 Coupling factor on various Ni electrodes structures/quartz at MR=0.8.

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was thin. Figure 6 shows their impedance characteristics. A bandwidth and a Q of No.1 of (a)structure is 0.050% and 6500. Ones of No.2 and 3 of (b) structure are 0.058% and 4000, and 0.042% and 6000, respectively. Compared with Q=13000 of (c) structure, their Q is low.[1)] Because their coupling factor and reflection coefficients at MR=0.8 are low as shown in Figs.2 and 3 composed with (c) structure.

3. Magnetic sensitivity

When the SAW resonator composed of (c) structure is received magnetic fields (Bx, By, and Bz) from X, Y, and Z directions, the resonant frequency shifts into the same direction only to increase of the By.[1)] Figure 7 shows the frequency shift of the four SAW resonators to the magnetic field By. The dependency of (c)conventional structure No.4 to the By is slightly different compared with the others. But there are no large difference, despite of low Q of (b) and (a) structure. It is considered that the sensitivity depends on the Ni electrode area as well as the increase of MR.

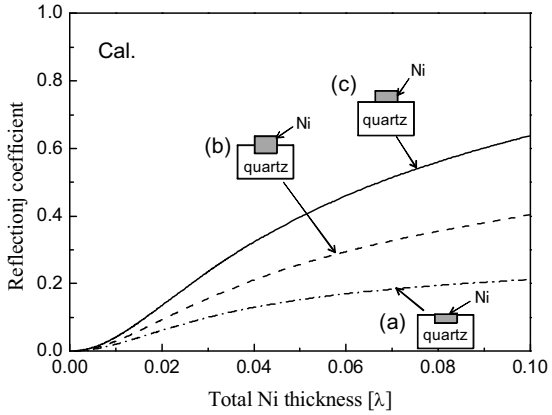

Fig.3 Reflection coefficient on various Ni electrode structure/quartz at MR=0.8.

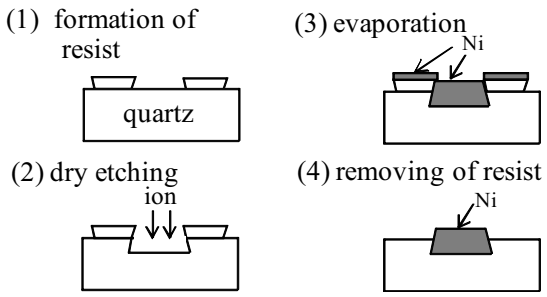

Fig.4 Process of fabrication of grooved electrodes.

Fig.5 Cross section of No.3 of (b) structure.

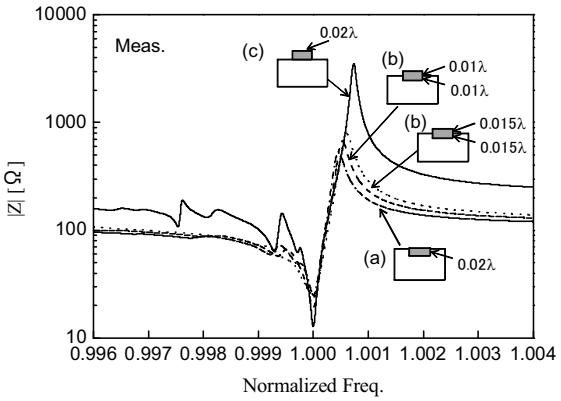

Fig.6 Impedance characteristics of No.1 to 4.

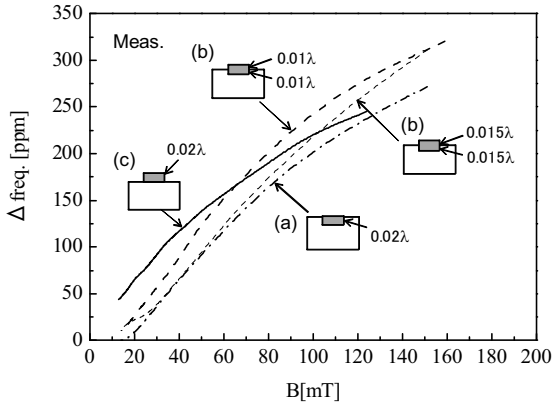

Fig.7 Resonant frequency shift of SAW resonators composed of various Ni structures/quartz as function of magnetic field.

5. Conclusion

The one port SAW resonators composed of the grooved Ni electrodes on the ST-90°X quartz and the additional Ni electrodes covered on it for magnetic sensors were fabricated. The frequency shifts of their resonators to the magnetic field strength were measured. It was clarified there are no large difference among 3 kinds of structures deposit of low Q of (a) and (b) structures.

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References

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