Effect of Magnetic Flux Concentrator on Magnetic Tunnel Junction Sensor for Magnetic Flux Leakage Testing

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Magnetic flux leakage (MFL) testing is a popular method for detection of defects such as the metal loss due to the corrosion in steel bars located in reinforced concrete. The magnetic flux leak caused by the defect is then measured by a magnetic sensor. However, as the distance between the defect and magnetic sensor (lift-off) increases, the strength of the leaked magnetic flux drops significantly, making it difficult to detect. A candidate of highly sensitive magnetic sensor to detect defects at the condition of large lift-off is the magnetic tunnel junction (MTJ) sensor. In this research, the MFL testing was carried out by MTJ sensor with high sensitivity.

The MTJ structure used in this research consists of a film structure of SiO_2sub. /Ta(5)/$Ni_{80}Fe_{20}$(70)/Ru(0.9)/$Co_{40}Fe_{40}B_{20}$(3)/MgO(1.6)/$Co_{40}Fe_{40}B_{20}$(3)/Ru(0.9)/$Co_{75}Fe_{25}$(5)/$Ir_{22}Mn_{78}$ (10)/Ta (8) (in nm) with a sensitivity of 267 μV/μT. Each MTJ was fabricated into the device with an area of 80×80 μm^2 and 5550 MTJ devices (1110 in series and 5 in parallel) were integrated to obtain a high signal-to-noise (SNR) ratio [1]. The fabricated sensor was attached to an acrylic push car and the scan was done along the length of reinforced concrete specimen. The output of the MTJ sensor was measured by conventional DC four-terminal method.

Fig. 1 shows the change of the output voltage from the MTJ sensor measured at lift-off of 20 cm according the magnetic flux leaking from the specimen. As shown in Fig. 1, the defect's location can be identified as the change of the voltage from the MTJ sensor. We found that the defects were detected by our MTJ sensor with a high SNR and installing a magnetic flux concentrator significantly improved the SNR until lift-off of 20 cm. We demonstrated the MFL testing with a high SNR using the MTJ sensor and the detection of defects under the condition with larger lift-off value can be realized by the improvement of sensitivity of the MTJ sensor.

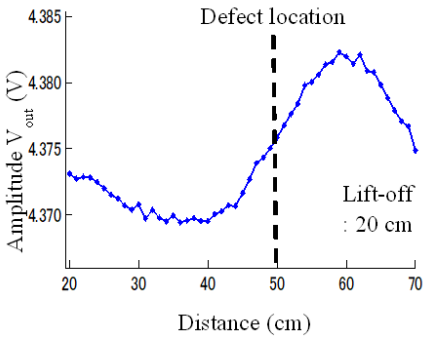

Figure 1: The amplitude of signal output from MTJ sensor

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