Current-controlled domain reconfiguration in small permalloy patterns

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In this study, we report current-induced tri-stable domain configuration of small permalloy islands. When the length-to-width ratio is near two, the magnetic domain uniquely sets into either 4 or 7 closure domain configuration by applying 10 ns current pulse at the density of 10^7 A/m^2 [1]. Fig. 1 shows the middle part of MFM images and corresponding schematic diagrams of magnetic domain configurations. As shown in center image of Fig. 1, the 4-domain configuration was observed prior to pulse application. This state changed into the 7-domain configuration (7D+) as shown in right image of Fig.1 after applying a single pulse of current density of +5.2x 10^7A/cm^2. After applying opposite direction of same amplitude current, the 4-domain structure was changed into 7-domain configuration (7D-) as shown in left image of Fig. 1. This 7D- structure has different chirality (sense of rotation) from right image (7D+). Furthermore, when two positive pulses are applied to 7D- configuration, the structure was set into 7D- configuration. The reverse process is also possible, if the two negative pulses are applied. Applying a large current pulse (8.0x 10^7A/cm^2) instead of two small current also can change the chirality of 7-domain. The main mechanism is domain motion due to s-d exchange force directed along the electron flow. Actually, the shaded part in the diagram moves to the opposite direction of the current pulse. This discovery suggests a potential memory device that can be selectable by current pulse. We observed 7D and 4D transition as small as 1um x 2 um rectangle. However, appropriate selection of amplitude and polarity makes possible to have bi-stable transition for memory device.

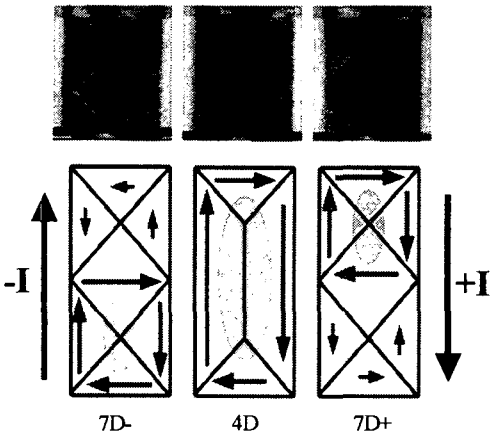

Fig.1. Current-pulse-controlled magnetic domain configuration.

References

[1] H. Koo, C. Krafft, and R. D. Gomez, Appl. Phys. Lett. **81**, 862 (2002).