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Real-time direct observation of temperature-dependent domain reversal behaviors in epitaxial MnAs film on GaAs(001)

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The MnAs film grown on GaAs substrate is of considerable interest due to their spintronic device applications for spin injection.[1] Recently, in this film, it has reported that two structurally distinct phases (hexagonal α-MnAs and orthorhombic β-MnAs) coexist with the form of self-organized periodic stripes of two phases in the temperature range of 20 ~ 45。 C, via strain-stabilization.[2] Numerous experimental investigations on the magnetic property of the film have performed to understand the magnetic domain structure. However, the time-resolved domain reversal study on the film wasnt investigated yet. In this Letter, we have carried out the real-time direct observation of the temperature-dependent domain reversal behaviors in the epitaxial MnAs film on GaAs(001) by means of magneto-optical microscope magnetometer (MOMM).

The epitaxial MnAs film with the thickness of about 50 nm was grown on GaAs(001) substrate at about 270。 C by a molecular-beam epitaxy (MBE). The strain-stabilized coexistence of two MnAs phases existed in the film was confirmed from the temperature-dependent x-ray diffraction (XRD) experiment. Here, we find that two phases coexist with systematic variations of their volume ratios with temperature in the temperature range of 20 ~ 40。 C and at T = 45。 C the complete phase transition to b-phase is done. The time-resolved magnetic domain patterns during the domain reversal were directly observed on the sample area of 80×64 μm^2 using a MOMM with ×500 magnification capable of capturing domain images with an image-grabbing rate of 30 frames/sec in real time and a spatial resolution of 400 nm, via longitudinal magneto-optical Kerr effect.

The detailed microscopic domain reversal behaviors were investigated from the direct observation of the time-resolved domain patterns using MOMM. Figure 1 shows typical domain reversal patterns with temperature in the temperature range of 20 ~ 40。 C, observed on the exact same area of the MnAs film. Strikingly, it can be vividly seen that as T increases the domain reversal behavior exhibits the domain wall (DW) motion process with the saw-tooth type and then, become changed to the domain nucleation process, as clearly depicted in Fig. 1. This change in the domain reversal process with T can be explained by two facts as follows: the decrease of the dipolar interaction with increasing T and the disconnection of the FM α-MnAs stripes at high temperature near the FM transition temperature (T_C ~ 45。 C). In the DW motion process region, the saw-tooth DW angle 2Φ during the domain reversal appears to be increased with increasing T, which is caused by the decrease of the dipolar interaction energy with increasing T.

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FIGURE CAPTIONS

FIG. 1. The variations of the typical domain reversal patterns with temperature in the temperature range of 20 ~ 40 oC, observed the exact same area of the MnAs film.

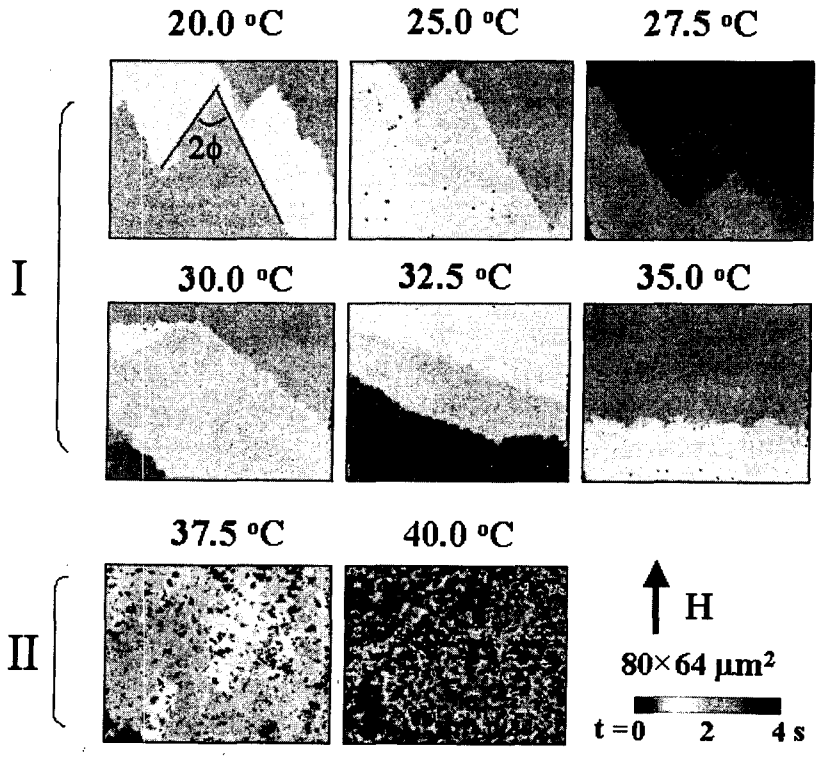

FIG. 1