Antireflective subwavelength structures on GaAs using a thermally dewetted Ag nanoparticle

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Abstract We fabricated subwavelength structures (SWS) on GaAs substrate using a thermally dewetted Ag nanoparticle for broadband antireflection purpose. The Ag nanoparticles formed by thermal dewetting were used as an etch mask for dry etch process to fabricate antireflective SWS. The tapered pillars on the GaAs were fabricated, on average, with distances below 200 nm, satisfying the required antireflection condition.

The Fresnel reflection of incident light comes from the large refractive index discontinuity at the interface of two media. The high refractive index of GaAs results in the reflection of up to 40% of the incident light, which severely limits the performance of GaAs based optoelectronic devices. Thin film coatings are commonly utilized to suppress undesired Fresnel reflection. However, the stabilityproblems induced by adhesiveness and thermal mismatch are often associated with such approaches. Recently, subwavelength grating structures (SWS) with dimension smaller than the wavelength of incident light have been considered an alternative to thin-film coatings, which are more stable and durable than surface coatings [1-6]. For the fabrication of SWSs, e-beam or laser interference lithography is usually used. However, the practical applications are highly restricted by the high cost or the complications of the procedures. In this study, we propose simple and low-cost fabrication method for antireflective SWSs on GaAs using thermally dewetted Ag nanoparticle.

For SWS fabrication, Ag films with thickness of 5, 10, and 20 nm was deposited on the SiO2 (50 nm) coated GaAs surface by using e-beam evaporator. The samples were heated at 500℃ for 1 min under a nitrogen atmosphere in order to form separated nano-particles. Then, the dry-etching of a SiO2 film was conducted in the reactive ion etcher (RIE) using CF4/O2 gas mixture. Subsequently, the underlying GaAs were also etched using inductively coupled plasma (ICP) etcher with a laser interferometer system at an optimum condition, i.e., SiCl4 (7.5 sccm)/Ar (2.5 sccm) with rf power of 50W and ICP power of 200W. The residual Ag/SiO2 mask was removed using buffered oxide etcher (BOE). The scanning electron microscopy (SEM) measurements were performed to observe the thermally dewetted Ag nanoparticle and antireflective SWSs.

In order to clarify the characteristics of the Ag particle, we measured the diameter of Ag particle and the distance between each nearest particles using SEM images. The average diameter of Ag particle varies with about 50, 100 and 200 nm as the initial film thickness increase with 5, 10 and 20 nm, respectively. The distance between each nearest particle also increases as the initial film thickness increase. This implies that the diameter and period of Ag particle can be controlled by changes of the initial film thickness. The fabricated SWS with conical profile have the period of ~200nm and the height of ~300 nm. The reflectance of the fabricated SWS was measured using UV-VIS-NIR spectrophotometer (Cary 500, Varian). The reflectance in the band of 300-1100 nm is below 6%, which is obviously decreased from above 30% for the flat GaAs. This result indicates that the thermal dewetting process has potential for the fabrication of antireflective SWS and its optoelectronic device applications.

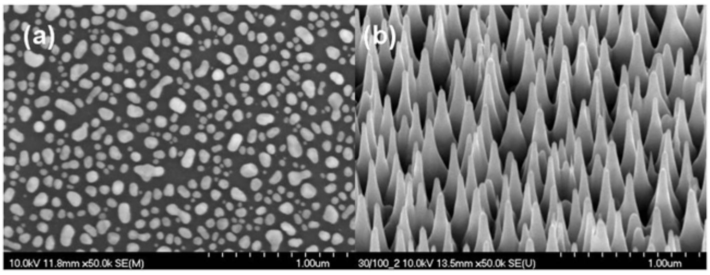

Figure 1. SEM images of (a) thermally dewetted Ag nanoparticles on GaAs substrated, (b) fabricated SWS with tapered profile on GaAs

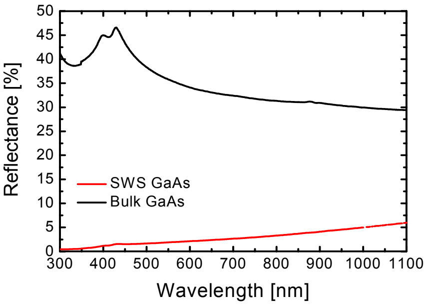

Figure 2. Measured reflectance of the bulk GaAs and SWS GaAs as a function of wavelength

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