18p-C3-1

Polarization Control over Deep Ultraviolet Light by Subwavelength Metallic Gratings

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Using subwavelength structures to manipulate the polarization of deep ultraviolet (DUV) light is generally known as difficult with the current nano-fabrication technologies. To ease the fabrication, an aluminum grating with its period slightly smaller than the DUV wavelength was designed to exhibit an inverse polarizing effect. At resonance, a pronounced inverse polarization extinction ratio of 35 dB was obtained in our experiment.

Introduction

Conventional wire grid polarizer (WGP), with its grating period much smaller than the wavelength of incident light, transmits (reflects) light that has an electric field vector perpendicular to (parallel with) the grating wires. Due to its compactness and ultrahigh extinction-ratio, WGP has been extensively used as linear polarizer and polarizing beam splitter in infrared and, recently, in visible band. However, in the deep ultraviolet (DUV) band (100–200 nm), a WGP with very fine grid of metal wires (say, with period <20 nm) has to be used, which makes the fabrication extremely difficult or even impossible with current technology. Here, we report on a subwavelength metallic grating (SWMG) that exhibits an inverse polarizing effect, i.e., with the TE transmittance η_{TE} exceeding the TM transmittance η_{TM} [1]. Unlike the conventional WGPs, the SWMGs have a period close to the incident wavelength, which eases the fabrication.

Experiments

Two samples, an Al grating with air slits (Al-air) and another with the slits filled with SiO_2 (Al-SiO_2), were fabricated using the standard nano-fabrication. The experimental results are demonstrated in Fig. 1. It is seen that both gratings exhibit pronounced inverse polarizing effect, which is caused by the selective coupling of incident light to TE guided mode [2]. As seen in Fig. 1(c), η_{TE} of the Al-SiO_2 grating (red circles) is substantially larger than that of the Al-air grating (black squares): an average of 45% increase in the DUV band is obtained. By filling the slits with the substrate material-SiO_2, the effective refractive index of TE guided mode approaching that of the SiO_2 substrate, leads to this increase in TE transmittance [3]. If we define the inverse polarization extinction ratio as $C=10\log_{10}(\eta TE/\eta TM)$, we achieve C=35 dB at λ=196 nm, seen in Fig. 1(d).

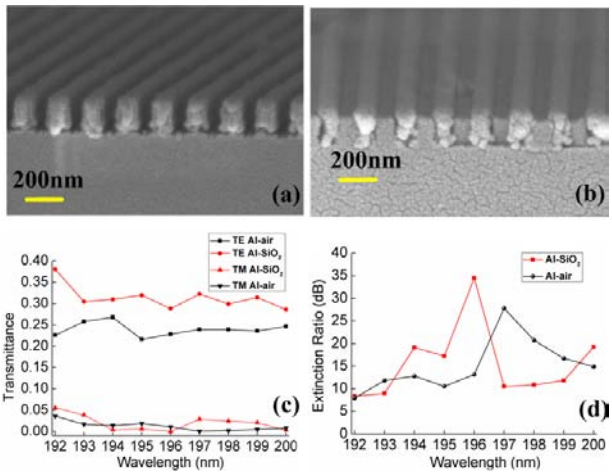

Fig. 1 SEM images of (a) Al-air and (b) Al-SiO_2 gratings. The experimentally measured (c) DUV transmittances and (d) inverse polarization extinction ratios of the Al-air and Al-SiO2 gratings in the DUV band.

Conclusion

The results presented here show that subwavelength metallic gratings with inverse polarization transmission can be applied in the DUV band, which suggest the possibility of DUV polarization control by compact and readily manufacturable grating structures.

Reference

[1] Guoguo Kang, et al. Appl. Phys. Lett. 99, (2011)

[2] Guoguo Kang, et al. Opt. Commun. 311 (2013).

[3] Guoguo Kang, et al. Appl. Phys. Lett. 103, 131110 (2013).