Antireflection structures for silicon coupling lens in near-infrared region using AlO_x/TiO_x bilayer grown by atomic layer deposition

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Silicon photonics has experienced rapid development with the progress of silicon (Si) technologies. In particular, the development of high-speed optical transceivers has attracted significant interest. Copper wiring for data transmission is currently replaced by Si-based optical fiber. Optical signals using light, instead of electrical signals, have been developed for communication. In general, when light from a light source is incident on an optical fiber, approximately 1.2 dB of the light intensity is lost [1]. In order to reduce this loss, an optical coupling lens is used. Owing to the advancement of silicon photonics, Si is mainly used for optical coupling lenses [2]. In Si, approximately 40% of the light intensity is lost owing to reflections at wavelengths of 1310 nm and 1550 nm, which are mainly used in optical communication. One approach to reduce the reflection loss is to introduce an antireflection (AR) coating on the lens surface [3].

In this study, we investigated the possibility of using an AlO_x/TiO_x bilayer as AR structures for Si, focusing on the wavelengths of 1270–1330 nm. The thicknesses of each layer were optimized by simulations using the Essential Macleod software. For experimental demonstration, atomic layer deposition (ALD) was used for the growth of AlO_x and TiO_x. The AR structure lowered the reflectance, close to 0%, at the wavelength band of 1270–1330 nm, which enabled an increase of the transmittance by approximately 40%, compared with bare Si. Despite the low reflectance close to 0%, transmittance of ~88%, which is slightly lower than expected, was obtained. An additional air annealing at 300 °C for 2 h led to a crystallization of the amorphous TiO_x into anatase phase, which yielded an improved transmittance of ~99%. Fig. 1 shows the reflectance and transmittance spectra of fabricated AR structure on Si; (a) bare Si and AlO_x/TiO_x AR structure, (b) AlO_x/TiO_x AR structure of as-deposited and annealed at 300 °C for 2 hr.

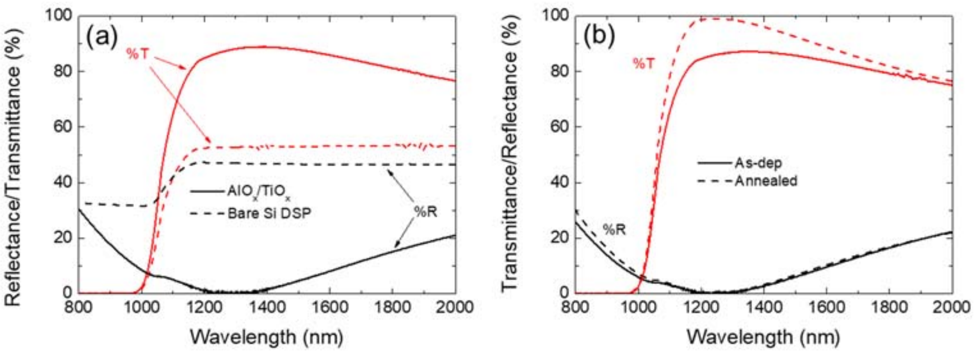

Fig. 1. Transmittance and reflectance spectra; (a) bare Si and AlO_x/TiO_x AR structure, (b) AlO_x/TiO_x AR structure of as-deposited and annealed at 300 °C for 2 hr.

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