Physically micromachined silica-on-silicon integrated corner mirrors

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Turning or corner mirrors can be used to redirected light on an integrated chip, providing a route to higher density of optical components. Mirrors have been demonstrated in silicon-on-insulator with losses of 0.9dB [1] and in hollow waveguides with losses of 0.8dB [2]. We demonstrate an alternative method of fabricating mirrors on a silica-on-silicon substrate. The method employs the complimentary techniques of physical micromachining and direct UV writing, both provide rapid prototyping outside the cleanroom environment.

The corner mirrors presented here are cut into the silica-on-silicon substrate using a precision dicing saw designed for use in the semiconductor industry. The diamond impregnated blades can produce grooves with highly vertical sidewalls with a low surface roughness (R_a) < 30nm [3]. The channel waveguides of the integrated circuit are defined post micromachining via direct UV writing with a 244nm argon ion laser. During this writing process the edges of the grooves are precisely located via monitoring of the reflected UV light from the sample surface.

A prototype sample was fabricated in a silica-on-silicon substrate where the planar core layer is doped with germanium and boron to provide UV photosensitivity. Two grooves are physically machined at 90º with respect to each other and the waveguides are then defined using direct UV writing. The UV writing technique can also produce Bragg gratings within the channel waveguides. These provide a precise route for measuring the loss of the mirrors by a nondestructive, ratiometric loss measurement technique [4]. A schematic of the device showing the location and wavelength of the gratings is shown in Fig. 1 (a). The broad spectral range of the multiplexed Bragg gratings provides loss information about the transmission bandwidth. The Goos-Hänchen shift at each mirror interface is accounted for by a waveguide offset designed for 1550nm [5].

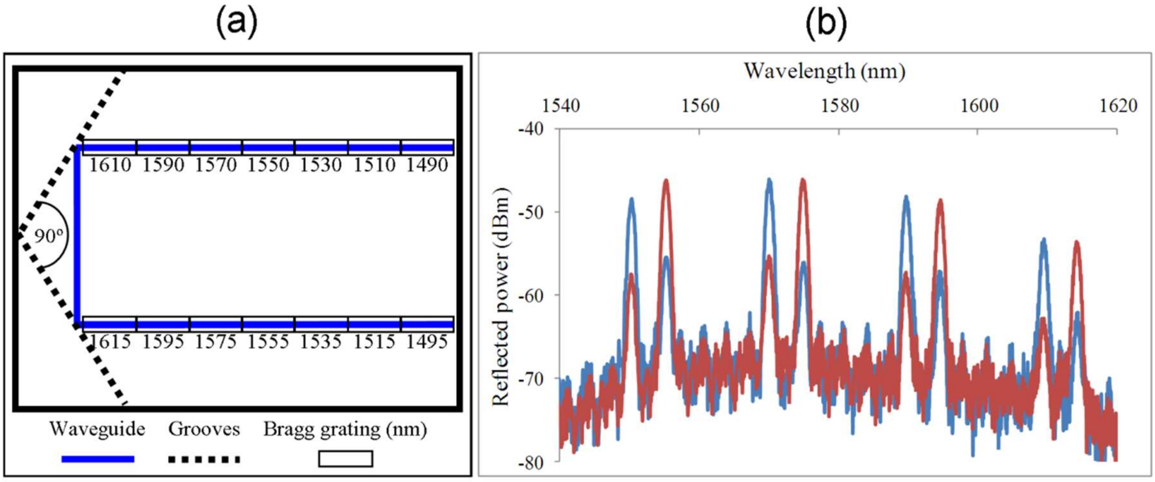

Fig. 1 (a) schematic showing waveguides, Bragg wavelengths and corner mirrors, (b) partial reflection spectra of the Bragg gratings collected from each direction.

To characterise the loss of the device a broadband light source (1480 to 1630nm) was sequentially launched into each facet of the device and the reflection light is spectrally analysed, see Fig. 1 (b). The Bragg gratings are fitted using a Gaussian fitting algorithm by which the ratio of their amplitudes are taken and from which the insertion loss of both mirrors can be calculated. The TM mode insertion loss for both mirrors was found to be 1.88dB, implying an individual mirror loss of ~0.96dB for wavelengths between 1550nm and 1615nm. This result is comparable to prior results [1,2]. By optimising the waveguide offset and reducing the sidewall roughness via techniques such as rapid thermal annealing the insertion loss can be further reduced. We shall present our latest results in the fabrication and characterisation of these corner mirrors.

References

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