Silicon-based integrated optical devices

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Using silicon substrates and conventional integrated circuit fabrication techniques to make integrated optical components offers substantial advantages in terms of reduced manufacturing costs. In this paper we report the development of passive integrated optical devices using two different silicon-based technologies - SiGe epitaxial layers and silicon-on-insulator (SOI). For both of these, this includes the first demonstration of optical waveguide fabrication using local oxidation of silicon (LOCOS), which is a standard processing technique for silicon integrated circuits.

In most respects SOI is the preferred material for optical waveguide layers because it is not subject to the lattice strain that is present in SiGe layers. In SOI it is relatively easy to make single mode wavguides with very low birefringence and cross-sectional areas that are well matched to optical fibers. We report the design and fabrication of arrayed waveguide grating (AWG) demultiplexers in SOI. A particular advantage of this material system is that the large refractive index contrast between the waveguide core and cladding allows the radius of curvature of curved waveguide channels to be as small as 200 microns. An eight channel AWG demultiplexer centered around λ= 1550 nm was made with a size less than 5 x 5 mm.

SiGe waveguide layers are necessarily strained due to the lattice mismatch between the alloy and the silicon substrate. This leads to a high degree of strain induced birefringence in the waveguides and to misfit dislocations that contribute to optical loss. Nevertheless, it is possible to control these losses sufficiently to use SiGe for passive integrated optical devices, as demonstrated by a dual-wavelength demultiplexer.

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