Abstract

Design and development of SU-8 polymer and silicon waveguide-based devices are undertaken in this thesis work. Design of these step-index waveguides for both transverse electric (TE) and transverse magnetic (TM) polarizations has been accomplished using effective index based matrix method; and the results are validated with finite difference time domain method. Initial fabrication attempt for obtaining single-mode SU-8 waveguides is made using laser direct writing technique on thermally oxidized silicon substrate with 375 nm continuous-wave laser source. Measured propagation losses of PDMS- and air-cladded SU-8 wire waveguides of 5.3 μm width and 1.35 μm thickness are 0.30 dB/mm and 0.51 dB/mm respectively. From measured mode profiles of single-mode SU-8 waveguides, refractive index profiles and mode index of waveguide have been extracted at 1550 nm wavelength, which match reasonably well with designed values. A feasibility study with focused ion beam lithography shows that it is well-suited to fabricate photonic crystal structures or making any precise modifications in micro- and nano-scale photonic waveguide structures, rather than fabricating conventional long waveguides. Proceeding with I-line optical lithograpgy using chrome mask, optical directional coupler, laterally-coupled microring resonator (MRR) and a photonic crystal structure on SU-8 waveguide are developed using plasma enhanced chemical vapour deposited oxide layer on silicon substrate. Characterization of MRR has been performed using a simple setup consisting of a semiconductor laser diode emitting 1550 nm wavelength, grating monochromator, and InGaAs detector. Obtained free spectral range of MRR for TE mode is 16nm, which matches well with the simulated value of 16.76 nm. Through port of this fabricated MRR can be used as an optical bandpass filter around 1565 nm transmitting wavelength with a 3-dB bandwidth of 5.36 nm. Photonic crystal structure fabricated by focused ion beam lithography on SU-8 wire waveguide may be applied in optical integrated circuits as input/output light coupler. A three-waveguide polarization-independent power splitter using coupled-silicon rib waveguides on silicon-on-insulator platform of device layer thickness 5 μm, has been designed and demonstrated. Measured total insertion loss and power imbalance between output ports for transverse electric and transverse magnetic modes confirm the polarization-independent behavior of the device.

Keywords: single-mode waveguide, rib waveguide, wire waveguide, mode index, bent waveguide, coupled waveguides, micro-ring resonator, photonic crystal, power splitter, effective index based matrix method, refractive index profile, polarization-independent, I-line lithography, laser direct writing, focused ion beam lithography, cut-back method, SU-8, silicon photonics.