Integrated chirped Bragg gratings with control over complex reflectivity

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Dispersion control in integrated optical systems is an important consideration, especially with the increasing complexity of such systems with many interconnected components. In addition, pulse dispersion control is necessary if semiconductor mode-locked lasers are to produce transform limited pulses[1]. One component that may be employed for these purposes is the integrated chirped Bragg grating (CBG). Integrated gratings are desirable for a number of reasons. They negate any necessity to couple off chip to fibre or bulk optic based dispersion control devices, and moreover, they present a unique bandwidth and dispersion region of operation compared to other technologies; and one which coincides with the typical characteristics of semiconductor mode-locked lasers[2].

In this work a fully post-growth device grating geometry based on etched sidewall gratings[3] is presented. The grating is written on a ridge waveguide with the grating recess depth, d, and the waveguide width, W, being design parameters, as shown in Fig.1(a). The grating coupling coefficient, κ, and Bragg condition, $\lambda_B=2n_{eff}\Lambda_0$, are necessarily related to the grating design parameters through the overlap of the propagating mode with the grating cross section. The Bragg condition may be controlled through the modal effective index, and the coupling coefficient as a function of the grating confinement factor. However, both of these effects rely on both d, and W. Therefore, by finding coupled sets of the design parameters to give the required local values of κ and λ_B, gratings with arbitrary amplitude and phase responses may be constructed. By using the waveguide width and grating recess depth to control the grating parameters the structure may be written with a single longitudinal period, Λ_0, and, therefore, does not require extremely involved lithographic techniques to induce the wavelength chirp[4].

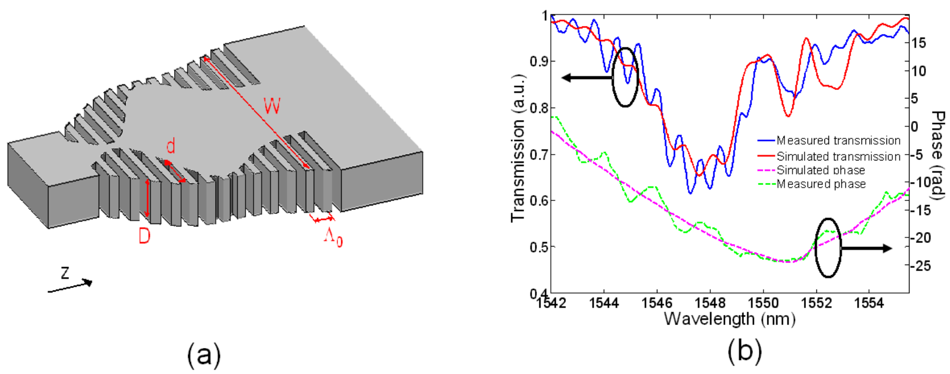

Fig. 1. (a) Schematic of a chirped and apodised sidewall grating, (b) measured and simulated transmission and phase spectra for a non-linearly chirped and apodised grating device.

In order to illustrate the potential of this technique, a number of device geometries were fabricated using Electron Beam lithography into HSQ resist, and subsequent Reactive Ion Etching with $SiCl_4$ to transfer the pattern into a 75:25:75% passive $Al_xGa_{1-x}As$ wafer. The gratings were etched 1μm below the waveguide core to ensure high overlap of the mode with the grating area. Devices were designed to exhibit linear or zero chirp, and Gaussian or zero apodisation of κ. Using these four conditions as bases, all of the combinations therein were fabricated, allowing isolation of either chirp or apodisation, or combinations of the two, to be measured. In addition a device geometry was fabricated showing both non-linear chirp and apodisation, the transmission spectra and phase response of which is shown in Fig.1(b), along with the simulated results from a Transfer Matrix Method model. The gratings were characterised by fabricating them within a folded Mach-Zehnder envelope structure that allows probing of both the amplitude and phase response of the grating in reflection.

Deeply etched sidewall gratings were shown to exhibit complex reflectivities that can be designed by recourse to the grating physical parameters. They are a fully-post growth technology that may be easily incorporated into laser and device fabrication using current lithography and etching processes.

References

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