Direct refractive index measurement technique to observe waveguide dispersion characteristics of short waveguides utilising the higher order modes of integrated Bragg grating structures.

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Measuring the dispersion characteristics of a planar waveguide is typically difficult due to the short lengths of waveguides involved. Traditional dispersion measurement techniques were developed in fibre [1] and bulk glass [2], and thus do not take into account the intricacies of the short planar waveguide. The fibre techniques typically require far more material than is available in a short planar waveguide, resulting in an imprecise measurement. The bulk measurement techniques do not take into account the specific structure and dimensions of the waveguide under test, so again do not provide a realistic interpretation of the dispersion characteristics of a specific waveguide.

A dispersion measurement technique has been developed for short planar waveguides utilising integrated Bragg grating structures within the waveguide itself [3]. By fabricating numerous Bragg gratings over a wide range of central wavelengths within a short planar waveguide, a direct refractive index measurement of the waveguide at these wavelengths can be carried out, and the chromatic dispersion characteristics of the waveguide obtained, as can be seen in figure 1 below. The curve shows the fitted three-term Sellmeier equation,

\[
n^2(\lambda_0) - 1 = \frac{b_1 - \lambda_0^2}{\lambda_0 - a_1} + \frac{b_2 - \lambda_0^2}{\lambda_0 - a_2} + \frac{b_3 - \lambda_0^2}{\lambda_0 - a_3}
\]

where \(n(\lambda_0)\) is the wavelength dependent refractive index, \(\lambda_0\) the wavelength and \(a_i, b_i\) the Sellmeier coefficients. This device has dispersion at 1550 nm of 29.37 ps/nm.km, and a zero-dispersion wavelength at 1240.0 nm.

This method can be further developed to allow the effect of changing the waveguide dispersion to be observed. By saturating the photosensitive refractive index change exploited to create the waveguide and Bragg grating regions, the Bragg gratings exhibit higher order modes which are modified as the waveguiding conditions change. This will be observed in the reflected spectrum obtained from the Bragg grating, and thus in the chromatic dispersion characteristics of the waveguide.

Fig. 1 (a) Two-beam interference in the Bragg grating fabrication (direct grating writing) setup. (b) Dispersion curve obtained for UV-written silica-on-silicon using the Bragg grating measurement technique. The device has dispersion at 1550 nm of 29.37 ps/nm.km, and a zero-dispersion wavelength at 1240.0 nm.

We will present proof-of-concept for the higher order mode dispersion measurement technique. Further, we will apply the technique to measure the effect of waveguide dispersion on the chromatic dispersion of our UV written silica-on-silicon waveguides.

References