ABSTRACT

A lithium niobate-based, integrated optical network analyzer for the vectorial structure characterization of optical fiber Bragg gratings is reported. Frequency-dependent complex reflectance Jones matrix is measured by interferometry and transformed into time domain. From the impulse response matrix, the vectorial grating structure is determined by inverse scattering. Local dichroic reflectivity and birefringence are derived from this data. Knowledge of the vectorial nature of the refractive index modulation depth and phase should allow an improvement of the ultra-violet (UV) light illumination process and to effectively correct the phase mask stitch errors by longitudinally selective UV light post-processing, in order to fabricate chirped and/or apodized gratings which require the highest fabrication accuracy.

Especially, for vectorial structure characterization, integrated optical circuit based on *X*-cut, *Z*-propagation lithium niobate was proposed and developed in-house. It consists of a single-mode 1x2 optical power splitter and is integrated with a set of 3 TE-pass polarizers, a set of 2 phase shifters, and a TE-TM mode converter on each arm of the power splitter. Topological details of this integrated optical circuit are given in the dissertation. This integrated optical circuit along with a 3x3 fiber coupler forms a Mach-Zehnder interferometer. A 3x3 fiber coupler with three photodiodes at its output was chosen because it allows the most accurate phase measurement. Real and imaginary parts of the frequency-dependent complex reflection coefficient are calculated from two linear combinations of three (three-phase) photocurrents. The integrated optical phase shifters allows digital phase shifting and perform AC rather than DC measurement in order to increase sensitivity. On-chip TE-pass polarizers maintain a reference polarization and ensure that only phase-modulated light with a single polarization enters the mode converter sections of this integrated optical circuit. The integrated optical TE-TM mode converters act as calibrated polarization transformers and are used to generate the required polarizations for vectorial measurement. The reflecting devices under test are connected to the measurement interferometer by means of an additional coupler. Measurement setup also includes a wavelength meter for frequency correction. A cleaved bare fiber end has a small reflectivity, which is independent of the frequency and polarization, is used for calibrating the measurement setup. A uniform optical fiber Bragg grating at 1548.25 nm with a reflectivity >95% and a 0.2 nm bandwidth was characterized. From this the vectorial grating structure was obtained and these results are summarized in the dissertation.

TE--TM mode converters with endlessly adjustable coupling phases on the *X*-cut, *Y*-propagation lithium niobate are optimized by simulation studies for the highest electrooptic efficiency for distributed PMD compensation. Two-phase and three-phase TE—TM mode converters are compared, and the latter are found to have a slightly better electrooptic efficiency. If just a little differential group delay needs to be compensated then the compensation performance can be drastically improved if the compensator is realized in mixed ferroelectric crystals like lithium-niobate-tantalate where the birefringence can be tuned by varying Ta content y in $LiNb_{1-y}Ta_yO_3$. A Ta content y of up to 0.5 is good to realize a PMD compensator for about 160 Gbit/s. This solution is particularly advisable at data rates of 40 Gbit/s and beyond. The above in-house developed integrated optical network analyzer is also used to measure the frequency-dependent reduced Müller matrix of this in-house developed distributed PMD compensator. Such a reduced Müller matrix measurement allows to calculate the corresponding Jones matrix and hence the impulse response of the devices with polarization mode dispersion. From the latter, differential group delay profiles are determined by the inverse scattering technique. Some interesting DGD profiles are obtained and are summarized in the dissertation.