Stress birefringence in fiber ribbons

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Cables where several fibers (typically, 4–16) are collected in a ribbon allow cost reduction and mass splicing. Their wide use in the access network and, in perspective, in long-haul links, has drawn attention on all factors affecting their performance. Polarization mode dispersion (PMD) in fibers embedded in ribbons has already been investigated, but with contradictory results.[1–3] Still, all previous results appear to indicate that birefringence in fibers belonging to ribbons can be significantly affected by stress distribution in the ribbon itself, which depends on thermal and mechanical properties of the coating. We report new theoretical and experimental results, which reconfirm this conjecture. Birefringence is shown to depend strongly on the fiber position in the ribbon.

Theoretical results are based on a Finite-Element-Method numerical simulation, based on the theory of elasticity, and apply over the temperature range (15–31°C) where viscosity in all materials can be ignored. Central fibers are found to be under compression in the ribbon plane, while lateral fibers do not experience significant compression, as the ribbon coating is softer than silica. Birefringence can be estimated in a simple way from the stress distribution. Figure 1 shows that birefringence in lateral fibers is essentially temperature-independent, while that of central fibers is quite sensitive to temperature, and three times larger.

To validate these predictions experimentally, PMD measurements were performed on a 4-fiber ribbon, 2.5 km in length, loosely wound on a drum (100 mm in diameter) in a controlled-temperature chamber. The temperature was first kept at 15°C for several hours, to reach a steady-state stress distribution. Then, it was raised suddenly to 25°C (point * in Fig. 2). During the thermal transient, differential group delay (DGD) was measured every 5 min, for 6 hours.

Next, the temperature was increased further to 31°C (point ** in Fig. 2), and the test procedure was repeated. DGD sampled versus time during the thermal transients is shown in Fig. 2, where dots are experimental data and continuous lines are best-fitting fourth-order polynomials. In agreement with numerical predictions, internal fibers are about three times more birefringent, and more sensitive to changes in temperature. A further indication that the model is correct comes from a statistical analysis of DGD data collected with another technique, based on polarization-sensitive time-domain reflectometry.[2]

In conclusion, our work provides new experimental evidence, that fibers in ribbons can be affected by systematic stress birefringence, whose source is the coating shared by the fibers in the same ribbon.

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2. A. Galtarossa, G. Gianello, C.G. Someda, M. Schiano, "fiber ribbon cable by means of polarization sensitive techniques", *IEEE Photon. Technol. Lett.*, 1232–1234 1994.
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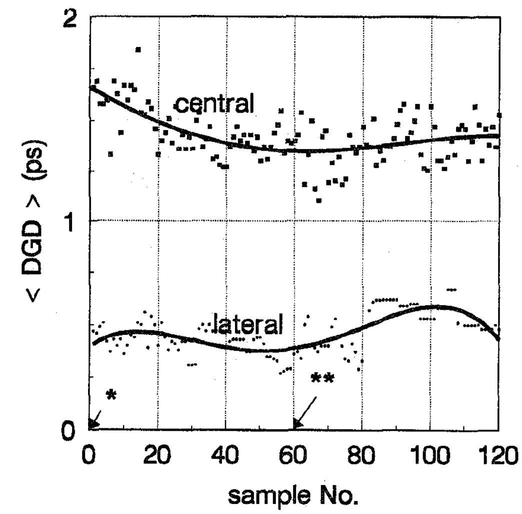
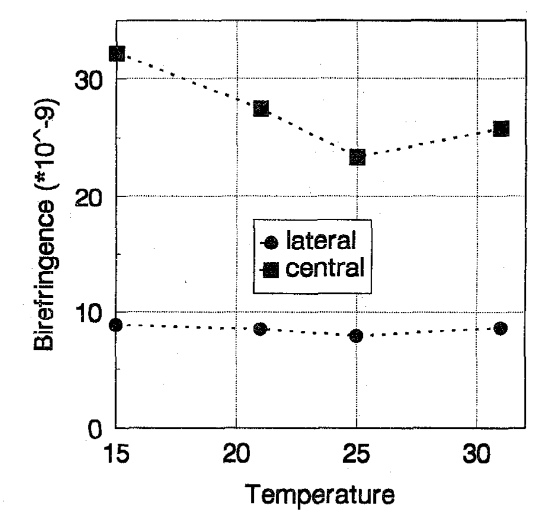


ThF7 Fig. 2. Measured DGDs; higher values (squares) refer to central fibers, lower values (dots) refer to lateral fibers. Continuous lines are fourth-order polynomial interpolations.



ThF7 Fig. 1. Stress birefringence vs. temperature: numerical results.

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Ballroom C2

Semiconductor Optical Amplifiers

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