Birefringence Induced in Optical Rib Waveguides By Thermal and Mechanical Stresses

G. Grasso[1], V. M. N. Passaro[1], F. De Leonardis[1]

[1]Photonics Research Group, Politechnic Institute of Bari, Bari, Italy

Abstract

Introduction
This work treats the study of the effect of thermal and mechanical stresses on guide-wave propagation in optical rib waveguides. In practical applications a rib waveguide is often in contact with a surface at higher temperature that causes heat flow into the device: this results in material's strain and, ultimately, in an optical birefringence. Besides, in many applications of such components, strain is also produced by a pressure that acts on the device. The situation is illustrated in figure, where F is the force applied on the device and Q is the heat propagating into it. A silicon-on-insulator rib waveguide is in contact with an aluminum layer through a silica layer; the heat flow is caused by the heated aluminum layer whose temperature is higher than that of the rib. The aluminum layer also transmits the pressure on the component. The stresses applied to the waveguide material structure cause each mode to be rotated. The study of birefringence is important for preventing or controlling it, often by limiting the stresses in the waveguide. Other techniques are based on a compensation of the birefringence by means of a birefringence with opposite sign.

COMSOL Multiphysics®
This model uses three modules of COMSOL Multiphysics®:
1) Heat Transfer Module - This module firstly studies the effect of heat transfer into the waveguide and calculate the temperature field in it.
2) Structural Mechanics Module - At this step the stress induced by the variation of temperature is related to the variation of the refractive indices along x and y (considering the plane stress), and then the birefringence. The total stress takes into account both contributions, i.e. thermal and mechanical force applied to the device.
3) RF Module - It calculates the effects of birefringence on the modes propagating into the waveguide. These can be seen by examining the modes that are obtained with and without the stress effects, and by the visualization of the power flow along the direction of propagation.

Results
The results will be visualized in waveguide cross-section plots. It will be interesting to observe the birefringence caused by either the thermal stress or mechanical stress, or both. This knowledge allows us to control such effects, for example by keeping the device below specific values of temperature and pressure.

Conclusion
The results will be very useful in applications where variations in optical device behavior due to thermal and mechanical stresses occur, such as thermal-optical modulators and SOI stressed waveguides.

Figures used in the abstract

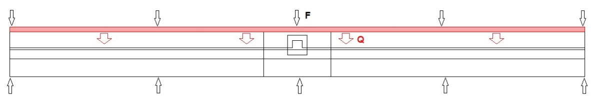

Figure 1: Figure