Cladding Layer Thickness Effect on Optical Performance in Ridged Waveguide

Xiantao Yan
LightCross, Inc.
2630 Corporate Place, Monterey Park, CA 91754, xyan@lightcross.com

Planar optical waveguides are key elements for integrated optical devices and semiconductor lasers. Stresses in waveguides, caused either by CTE mismatch or by different processing and doping conditions, have a significant effect on optical performance of photonic devices. In this study, our focus is on silicon based ridge waveguide, as shown in Fig. 1. This waveguide is consist of a square or rectangular core (Si) surrounded by a cladding (SiO_2) with lower refractive index than that of the core.

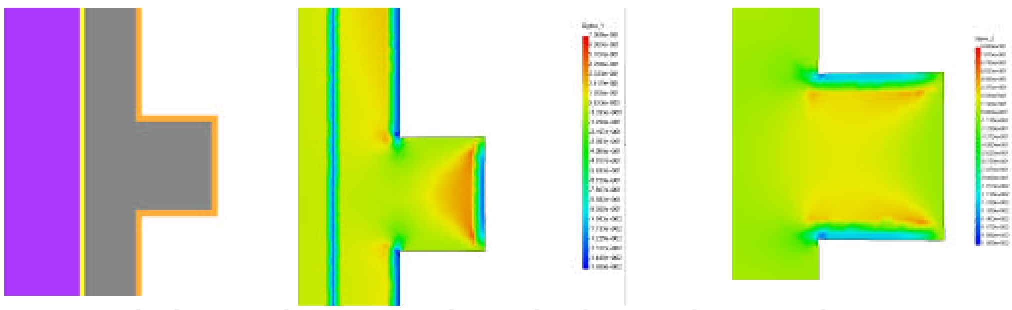

Fig. 1: A ridged waveguide structure, and stress distribution in the waveguide.

For a cladding of 0.5 µm, FEA results show that stresses in the waveguide result in a 10^{-3} refractive index change. This index change will have significant impact on optical performance. In order to reduce stress level in the waveguide, a lower processing temperature to form the cladding layer, i.e., plasma-enhanced chemical deposition, and a thinner cladding layer are recommended. For a waveguide structure with an Al coating on the top of the cladding layer, the cladding layer thickness has a significant effect on the optical performance. The Al layer thickness is 0.3 µm, and is formed at 380°C and then cooled down to 25°C. The SiO_2 layer is formed at 800°C and cooled down to 25°C. As shown in Fig. 2, there exists an optimized cladding layer thickness.

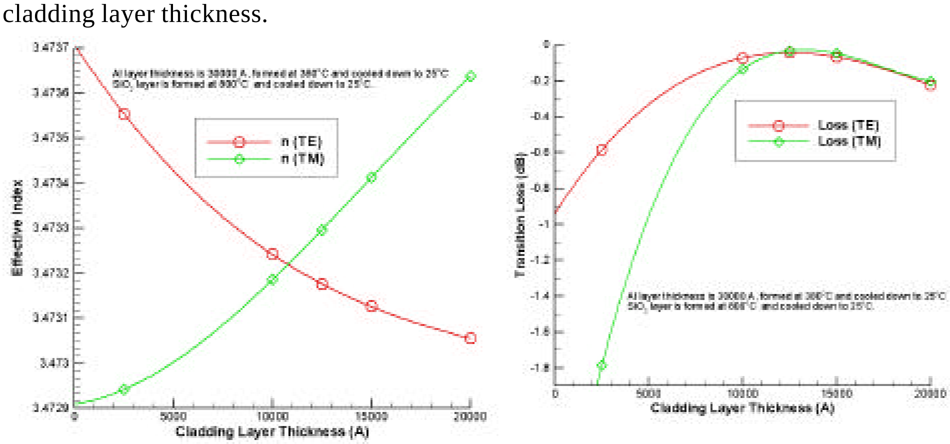

Fig.:2: Cladding thickness effect on effective index and transition loss.

The above results show stress effect on optical performance in photonic components and integrated photonic devices is much stronger than that in microelectronics, where there is no significant effect on electric performance as long as the stresses do not cause delamination or cracking. In the future photonic integration, we have to overcome or compensate the stress effect by material selection, processing and design.