Roughness in High Index-Contrast Waveguides

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An important issue in nanophotonic devices is accuracy in fabrication. Even the most advanced waveguides exhibit sidewall deviations of several nanometers [1-2], and this leads to attenuation due to reflection and to scattering into the radiation field. Unfortunately, standard numerical techniques such as FDTD require large amounts of memory and simulation time to accurately model the effects of sidewall roughness. We present instead results from a new perturbation model, which can be used to accurately predict the attenuation due to sidewall roughness in high-contrast integrated optical waveguides. Previous models of rough waveguides [3-4] have approximated the surrounding radiation field using radiation modes which are either two-dimensional or appropriate only for low-contrast materials, and this can lead to predictions which are incorrect by up to an order of magnitude. We construct here the fully 3D radiation

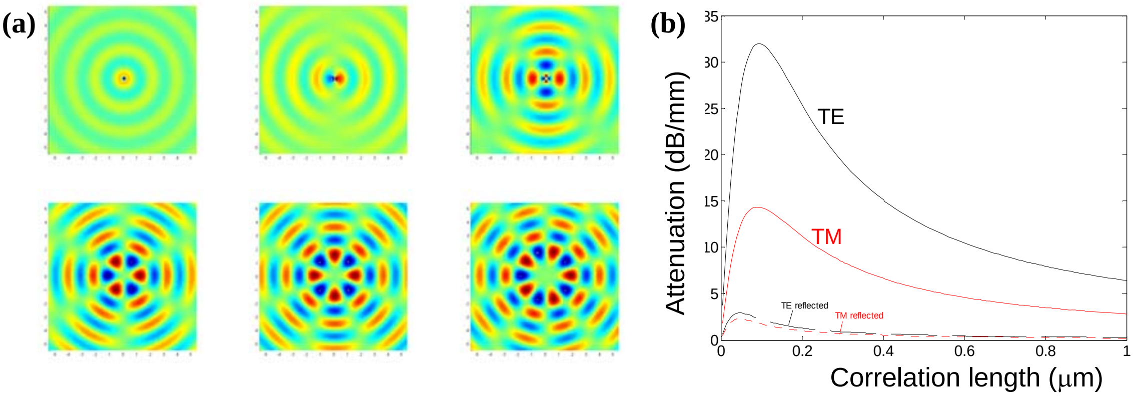

Fig. 1 **(a)** 3D radiation modes for reconstructing the scattered fields (**b**) Attenuation vs. roughness correlation length for a square silicon waveguide with width 0.42 µm and RMS roughness 5 nm

modes which are appropriate for square, high index-contrast waveguides (see Fig. 1a). This enables us to accurately predict the attenuation due to sidewall roughness (Fig. 1b), and leads to design rules for low-loss integrated optical waveguides. Using this model, we show that the dominant loss mechanism is radiation rather than reflection, and that the quasi-TE polarization is more severely attenuated than the quasi-TM polarization. We experimentally investigate the properties of sidewall roughness of an InGaAsP/InP pedestal waveguide, and the measured attenuation of this waveguide is then compared with the result predicted by the perturbation model.

References

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