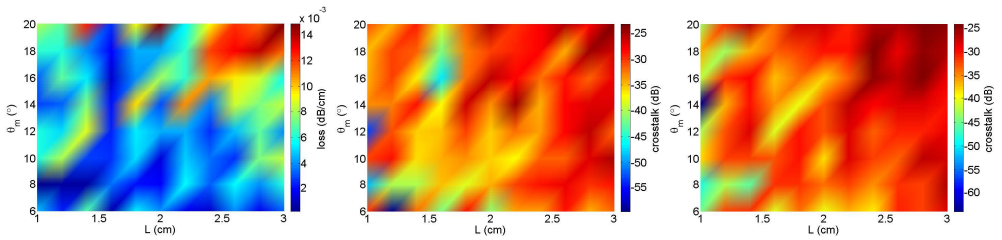


Fig. 8. (a) The loss value (in dB/cm) for the center channel. (b) The crosstalk value (in dB) for the right channel and (c) left channel.

After some calculations, we can conclude the maximum number of scattered rays plays a minor role in this simulation. Here, $N_s = 5$ is fixed and the scattering probability is determined to be 1%. We try to find the relationship among the propagation distance $L$, the maximum scattered angle $\theta_m$, and propagation loss. Figure 8 (a) shows when $\theta_m$ is smaller than 14 degrees, the propagation loss is as low as 0.01 dB/cm, and is almost independent on the waveguide length. Thus, we succeeded in modeling the copolymer based GI core waveguide shown in Fig. 3. Using these parameters, inter-channel crosstalk is calculated, and the results are shown in Fig. 8(b) and Fig. 8(c). As we expected, the crosstalk values are a little lower than −30 dB in the area where $\theta_m$ is smaller than 14 degrees. Meanwhile, with increasing the value of $\theta_m$, the crosstalk increases to −25 dB. Thus, it is obvious that the excess scattering loss of the waveguide significantly increases the crosstalk, and we find a good coincidence with the experimental result shown in Table. 1. Further theoretical analysis on the crosstalk, such as inter-core pitch, refractive index profile, or fiber NA dependences will be carried out utilizing this modeling tool, and then will be published elsewhere.

## 4. Conclusion

We fabricated a polymer optical waveguide with GI-circular cores using P(MMA-BzMA) copolymer for the core. Although the copolymer core possesses higher thermal stability in the refractive index profile than doped PMMA core waveguides, an excess scattering loss as high as 0.008 dB/cm is observed. Hence, we evaluated the influence of the excess scattering loss on the mode conversion and inter-channel crosstalk in the multi-channel GI-core polymer optical waveguide. The ray tracing method is utilized for the simulation. In the single channel condition, the calculated output NFP showed the optical confinement effect of the GI profile when no scattering was taken into account, while a significant NFP degradation was observed due to the mode conversion caused by the light scattering. For the multi-channel condition, the loss and crosstalk value can be clearly quantified by the similar way. The results encourage us toward further optimization processes and add more practical considerations.

Although the simulation of the inter-channel crosstalk was performed only on our GI-core polymer optical waveguides, it is capable of modeling the conventional SI rectangular-core waveguides. As we mentioned above, some amount of excess scattering is generally observed in the conventional SI-core waveguides, and thus, the application of this simulation to SI-core waveguides helps find a feasible design for high-density alignment of the waveguides.

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