Silicon photonics needs a harness

A. Melloni

Dipartimento di Elettronica e Informazione, Politecnico di Milano
Piazza Leonardo da Vinci 32, I-20133, Milano, Italy

In the last decade, silicon technology has dramatically emerged as a leading photonic platform for the fabrication of integrated optical devices.

This success is related to a powerful blend of properties, enabling large-scale integration of many optical and electrical functional elements on a single chip, and to a production process compatible with existing CMOS lines. However, there are still several issues that have to be solved in order to fully exploit the potential of silicon photonics to realize complex photonic integrated circuits (PICs).

As a first problem, silicon waveguides are extremely sensitive to fabrication tolerances, in such a way that even atomic scale imperfections can have a significant impact on PIC performance. Post-fabrication treatments are thus required to compensate for fabrication tolerances in order to target desired specifications and to get a high manufacturing yield.

In this work, we review our recent results on the permanent photo-induced trimming of silicon photonic devices assisted by chalcogenide glasses (ChGs). Selective exposure to visible-light is used to demonstrate the compensation of fabrication tolerances in complex integrated architectures and the realization of permanently reconfigurable PICs with no need for continuous active tuning. Devices fabricated on several ChG-assisted platforms are presented and issues related to trimming speed, saturation effects and time stability are discussed.

Further, we discuss the limits induced by two-photon absorption (TPA) in silicon waveguides in the near-IR wavelength range. While much attention has been devoted to TPA-induced nonlinear loss, refractive index variations induced by free-carrier absorption (FCA) thermal effects have been largely undervalued so far. We show that in silicon coupled resonator filters and delay lines, FCA-induced thermal effects are responsible for intensity dependent shifts of the resonant wavelengths, resulting in strong distortions of the frequency and time response. We also demonstrate that such effects can be effectively compensated by an active thermal control of the resonators, so that the designed device response is preserved regardless of the aggregate power transmitted through the device.