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Altermalization rolled-up TiO_2 microtube ring resonator for both visible and telecom photonics

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Abstract

One important concern in integrated optics is thermal heating which leads to the unwanted wavelength shift in the integrated system. This shift oftentimes is not suitable for some important applications e.g. optical filtering and switching and etc.. To this end, one needs to fabricate the athermal optical devices instead of the conventional optical devices in the integrated system. In this work, for the first time a hybrid TiO_2-SiO_2 and or (TiO_2-Si_3N_4) rolled-up microtube ring resonator (RUMRs) with a temperature insensitive resonance (i.e. athermal) is theoretically and experimentally demonstrated. In the first part of this paper, the thermal stability of optical filters based on self-assembled TiO_2 RUMRs by incorporating positive thermo-optic coefficient (TOC) materials (e.g. SiO_2 and/or Si_3N_4) is investigated. The influence of the TOC, refractive index, and thickness of the positive TOC materials on the filtering performance of the TiO_2 RUMRs are theoretically studied. The results illustrate that an increase in temperature leads to a blue-shift in resonant wavelength of the RUMR-based optical filter, which changes at a rate of -33.3 pm/K owing to the negative TOC of TiO_2 $(-4.9 \pm 0.5 \times 10^{-5} k^{-1})$. By increasing the thickness of SiO_2 or Si_3N_4 as a positive TOC material together with TiO_2 the temperature-induced resonant shifts (TIRSs) of TiO_2/SiO_2 and/or TiO_2/Si_3N_4 RUMRs are theoretically obtained. The TIRS varies between -40 pm/K (-22 pm/K) and about 30 pm/K (22 pm/K) for TiO_2/SiO_2 (TiO_2/Si_3N_4) RUMRs. It is shown that thermal stability occurs when the thickness of the SiO_2 (Si_3N_4) layer is ~16 nm (12 nm). In the end of this study, for a proof-of-concept, an experiment is demonstrated by fabricating isolated RUMRs (i.e. not coupled to the waveguides) based on TiO_2/SiO_2 on the flat silicon wafer. In order to study the resonance-temperature-(in-)sensitive, the fabricated devices are excited using He-Cd laser $(\lambda = 442nm)$ under different input power via a conventional micro-photoluminescence (µ-PL) setup. The experimental results are represented that by selecting the apricated thickness ratio of TiO_2/SiO_2, the non-shift (and/or athermalization) of the optical modes is achieved. It is also shown that by reducing (increasing) the thickness of SiO_2, the blue-shift (red-shift) of the optical modes is observed. This novel approach for athermalization of optical resonators opens up interesting perspectives toward the implementation of vertical and multi-routing coupling between photonic and optoelectronic layers and more specifically in a 3-integration fashion.

Biography:

Abbas Madani is a professor in Cambridge Graphene Centre, and studied in University of Cambridge, Cambridge UK.In 2014, he also joined the Institute Of Integrated Nanoscience and left in 2018.

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