Graphene as active material for modulation and photo-detection in integrated optoelectronic devices

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Silicon Carbide (SiC), with its superior electronic properties, is recognized as one of the most promising candidates for the new generation of optoelectronic devices. In the present work, a preliminary study about a graphene (Gr)/4H-SiC Schottky photodetector is presented together with a crystalline silicon (c-Si)/ hydrogenated amorphous silicon (a-Si:H) waveguide-integrated modulator based on a double-layer of Gr deposited inside the waveguiding structure.
In particular, we report about the fabrication and the electro-optical characterization of the first Gr/4H-SiC-based Schottky photodetector operating outside the 4H-SiC absorption spectrum taking advantage of the internal photoemission effect. The electrical characterization showed a good rectifying behavior of the diode, a Schottky barrier height of 0.55 eV and a series resistance of about 60 Ω. Photodetector responsivity/efficiency measurements were carried out at the wavelength of λ=406, 630 and 780 nm. Moreover, simulation results about an electro-optical modulation, at λ=1550 nm, achieved from a waveguide-rib integrated electro-absorption modulator (EAM) based on c-Si/Gr/a-Si:H multilayer structure, whose realization feasibility is enabled through the plasma-enhanced chemical vapor deposition (PECVD), is discussed. The theoretical analysis of such EAM was performed using FEM and FDM commercial solvers. 3 dB modulation was calculated in a small footprint device of 5 μm^2, a bandwidth of B=140 GHz has been estimated with an applied voltage of about 7 V.

For both devices, a look towards the industry-required integration of photonics into “standard” electronics, in a back-end of line (BEOL) process, is analyzed in order to overcome the matching issues with two-dimensional materials, such as Gr, as active photonic material.