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Plasmonic and Photonic Modes Excitation in Graphene on Silicon Photonic Crystal Membrane

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Graphene is a perspective material platform for the infrared (from far-IR to near-IR) optoelectronics due to possibility of extremely confined surface plasmons polaritons excitation at long wavelengths, and large (for atomically thin layer) optical absorbance of 2.3% in the short wavelengths ranges. Being deposited on a silicon photonic crystal membrane graphene serves as a highly promising system for modern optoelectronics with rich variety of possible regimes. Depending on the relation between the photonic crystal lattice constant and wavelengths (plasmonic, photonic and free-space) we identify four different interaction schemes. We refer to them as metamaterial, plasmonic, photonic and diffraction grating regimes based on the principle character of light interactions with the graphene deposited on the Si photonic crystal membrane. The optimal configurations for resonant excitation of modes in the most important for applications plasmonic and photonic regimes are numerically investigated. We also demonstrate fabrication of photonic crystal membranes, high-quality transfer of large area chemically vapor deposited graphene on them and their comprehensive Raman, AFM and FTIR experimental characterization. Measured data are well correlated with the numerical analysis. Combined graphene – silicon photonic crystal membranes can find applications for infrared absorbers, modulators, filters, sensors and photodetectors.