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Nanoscale Tunable Strong Carrier Density Modulation of 2D Materials for Metamaterials and Other Tunable Optoelectronics CHENG PENG, DMITRI EFETOV, REN-JYE SHIUE, Massachusetts Institute of Technology, SEBASTIEN NANOT, ICFO, the Institute of Photonic Sciences, MAREK HEMPEL, JING KONG, Massachusetts Institute of Technology, FRANK KOPPENS, ICFO, the Institute of Photonic Sciences, DIRK ENGLUND, Massachusetts Institute of Technology — Strong spatial tunability of the charge carrier density at nanoscale is essential to many 2D-material-based electronic and optoelectronic applications. As an example, plasmonic metamaterials with nanoscale dimensions would make graphene plasmonics at visible and near-infrared wavelengths possible. However, existing gating techniques based on conventional dielectric gating geometries limit the spatial resolution and achievable carrier concentration, strongly restricting the available wavelength, geometry, and quality of the devices. Here, we present a novel spatially selective electrolyte gating approach that allows for in-plane spatial Fermi energy modulation of 2D materials of more than 1 eV (carrier density of $n = 10^{14}\,\mathrm{cm}^{-2}$) across a length of 2 nm. We present electrostatic simulations as well as electronic transport, photocurrent, cyclic voltammetry and optical spectroscopy measurements to characterize the performance of the gating technique applied to graphene devices. The high spatial resolution, high doping capacity, full tunability and self-aligned device geometry of the presented technique opens a new venue for nanoscale metamaterial engineering of 2D materials for complete optical absorption, nonlinear optics and sensing, among other applications.

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