Tuneable Dot Platform for Controllable Electron Optics in Graphene

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We introduce the Tunable Dot Platform (TDP), a novel architecture designed to control the angle and magnitude of electronic current flows in graphene. The TDP consists of a 3×3 matrix of gated quantum dots embedded in graphene, where each dot potential value can vary independently within a range. The ability to manipulate each dot independently enables numerous dot arrangements, offering a diverse range of output currents at different distances and angles around the dot array. Our approach integrates analytical modeling and numerical simulations to propose a feasible design for graphene-based electron optic devices. A generalized Mie theory is used to describe scattering processes in the dot array. A key feature of the TDP is its programmability, which enables dynamic reconfiguration of dot potentials to achieve specific electron flow patterns, ensuring precise directional control. To optimize the TDP design, we utilize differential evolution (DE), an iterative computational algorithm inspired by biological evolution, to predict dot arrangements that maximize desired outcomes. Our study explores both far-field and local current distributions in graphene for specific targets. A range of different target behaviors are considered, including focussing and controllable angular scattering and beam splitting. These findings highlight the significant potential of the TDP for next-generation graphene-based electronic devices.

Figures

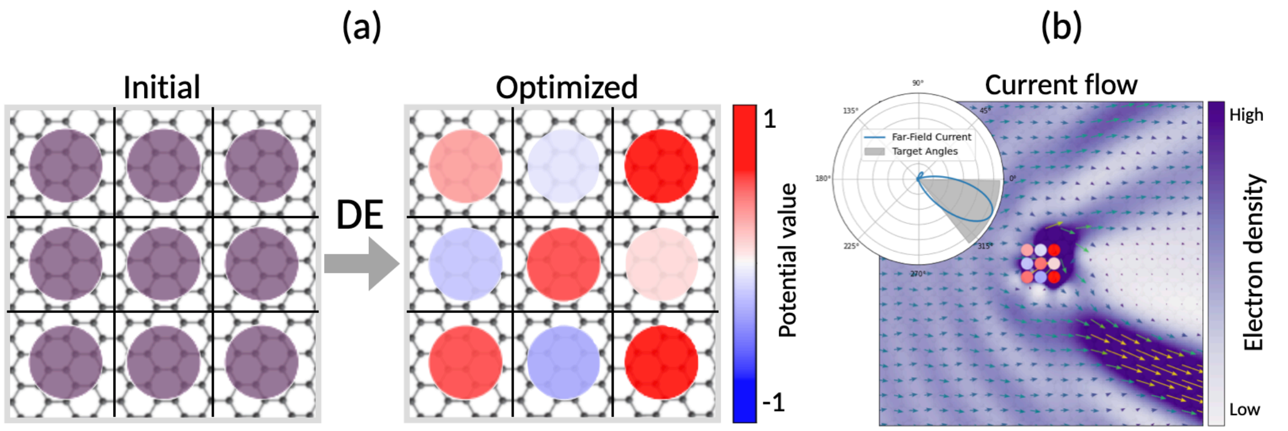

Figure 1: (a) A schematic representation of the optimized dot arrangement in TDP obtained via DE and (b) the corresponding current flow (arrows) and electron density distribution (color) in graphene. The inset shows the far-field current in target angles.