Engineering high quality graphene superlattices via ion milled ultra-thin etching masks

Rebecca Hoffmann[1]
David Barcons Ruiz[1], Hanan Herzig Sheinfux[1], Iacopo Torre[1], Hitesh Agarwal[1], Roshan Krishna Kumar[1], Lorenzo Vistoli[1], Takashi Taniguchi[2], Kenji Watanabe[2], Adrian Bachtold[1,3], Frank H.L. Koppens[1,3]

[1] *ICFO-Institut de Ciencies Fotoniques, 08860 Castelldefels (Barcelona), Spain*
[2] *Research Center for Functional Materials, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan*
[3] *ICREA-Institució Catalana de Recerca i Estudis Avançats, 08010 Barcelona, Spain*
rebecca.hoffmann@icfo.eu

Moiré superlattices in graphene have attracted a tremendous amount of attention, due to the observation of Hofstadter butterflies [1], and more recently, the discovery of superconductivity [2]. However, moiré systems are difficult to control and impossible to tune. An alternative, more versatile, approach is to engineer superlattices is by applying a periodic electrostatic potential, so both the lattice geometry and period can be designed as needed. But despite an extensive effort to push nanofabrication techniques in order to engineer artificial graphene superlattices, achieving periods below 40 nm remains an extreme challenge [3-4], making it impossible to explore the most exciting aspects of superlattice physics.
Here, we demonstrate a new nanofabrication technique able to pattern periodic structures with sub-20 nm pitch, approaching the moiré length scales [5]. Our technique combines He focused ion beam (FIB) indirect milling of ultrathin suspended hard masks with reactive ion etching (RIE), achieving ultimate FIB resolution and relatively damage free patterning. This allows us to generate clean and low-disorder lattices and avoid inducing damage in the gate material, allowing the graphene device to retain high mobility. Furthermore, by engineering a non-bipartite superlattice (here Kagomé), we observe electron-hole symmetry breaking in single layer graphene. Our technique opens the path to engineer exotic phenomena in single layer graphene, with symmetries not accessible in Moiré superlattices and dimensions well below the state of the art in nanofabrication.

References

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Figures

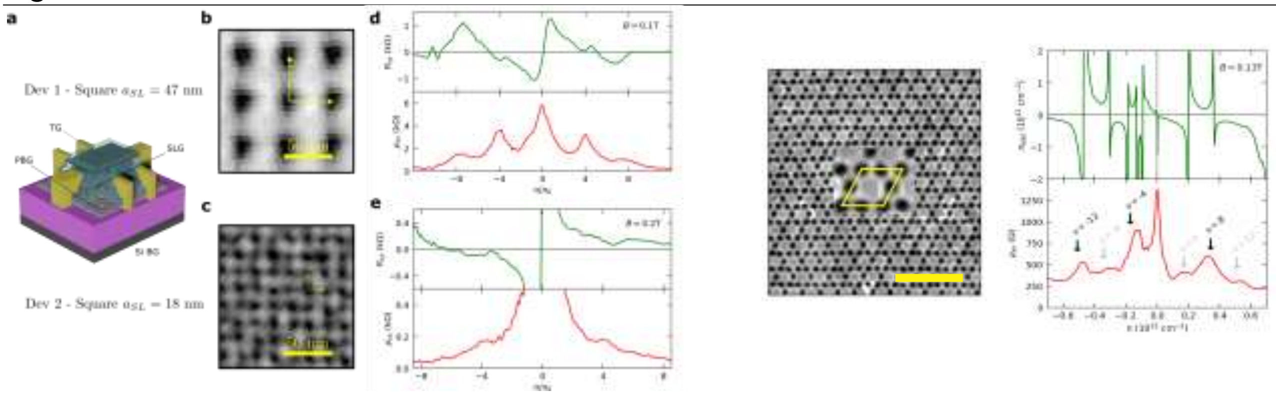

Figure 1: Device schematic, AFM topography of patterned gates and electronic transport characterization of artificial graphene square superlattices