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Assembling semiconductor twistronic superlattices through dry transfer printing of single-crystalline semiconductor nanomembranes derived from bulk wafers

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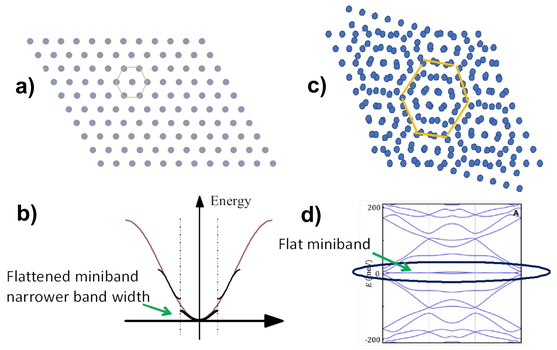
ABSTRACT

Our goal is to develop a wafer-scale transfer technique that enables: 1) twistronics made of dissimilar single-crystalline semiconductor bilayers that are difficult to grow by Molecular-beam epitaxy (MBE) method; 2) semiconductor twistronic superlattice structures that are beyond the epoxy bond and stop-etch (EBASE) capability. Our approach will create a new way to form twistronic structures far beyond current approaches and allow us to explore more exotic quantum phenomena.

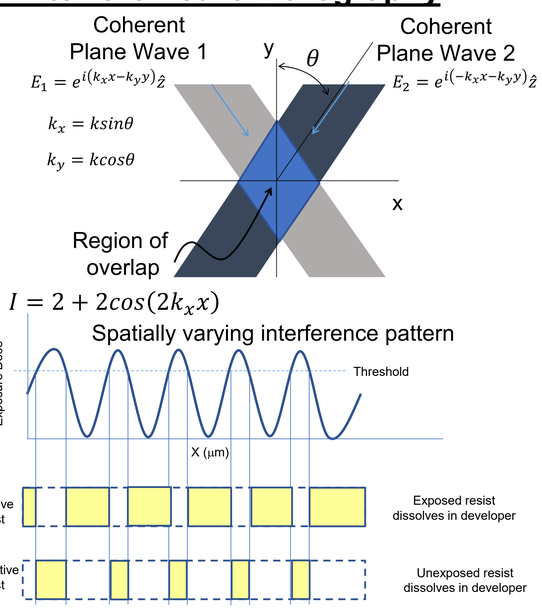
I. INTRODUCTION

a. Artificial graphene-Twistronics

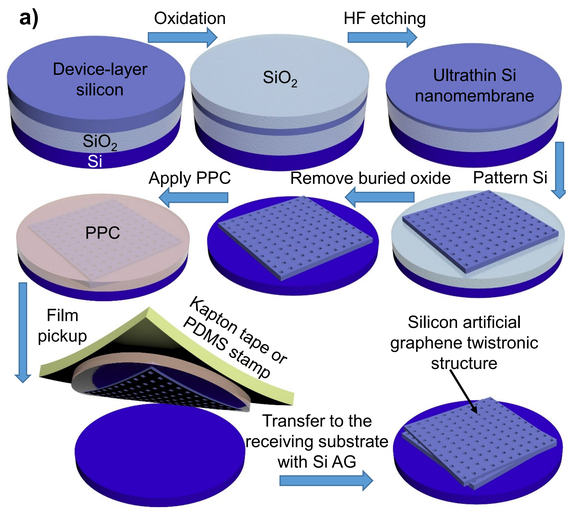


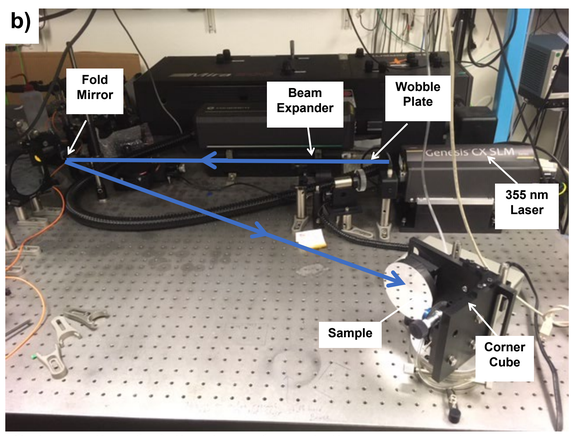
(a) Schematic representation of artificial graphene (AG). The blue dots form a honeycomb structure, as indicated by the yellow lines **(b)** Formation of flattened mini-band with a narrow band width. **(c)** Twisted bilayer AG with a twist angle of 15º. **(d)** Expected flat miniband formation in twisted bilayer AG.

b. Interferometric Lithography



II. EXPERIMENT





Schematic of **a)** the transfer printing process to fabricate twistronics superlattice and **(b)** the simple Lloyd's Mirror setup utilized in interferometric lithography.

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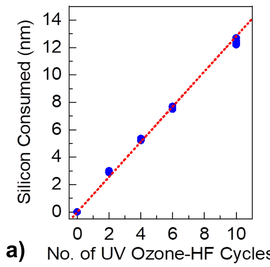
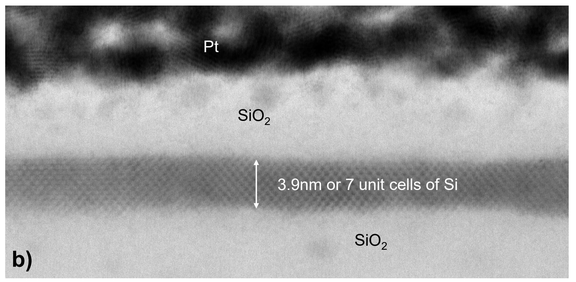
III. RESULTS

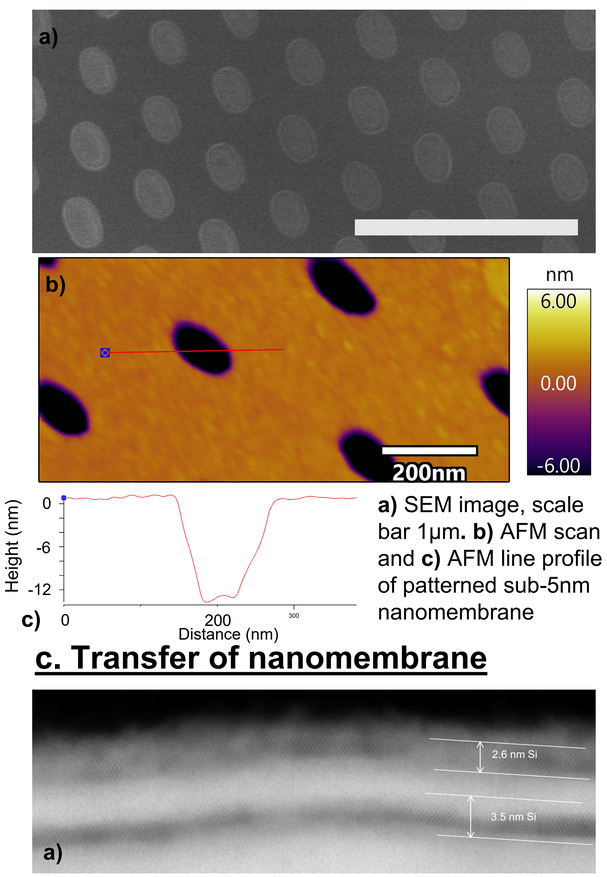
a. Ultrathin-single crystalline Si nanomembrane



a) Silicon consumption rate as a function of UV Ozone-HF cycles. **b)** Cross-section STEM bright field image of the formed freestanding silicon nanomembrane.

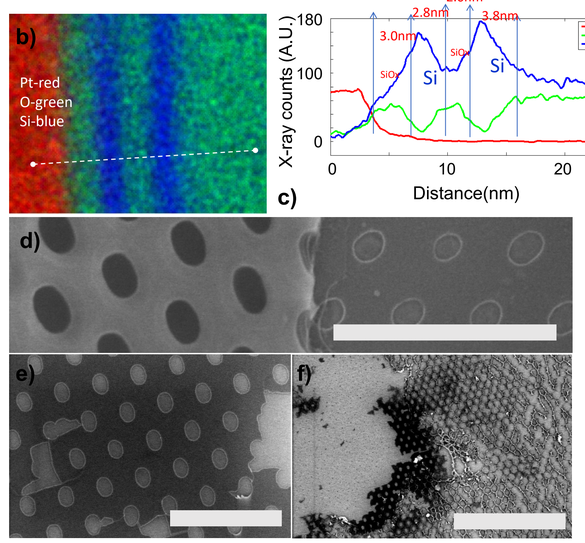


b. Patterning Si nanomembrane



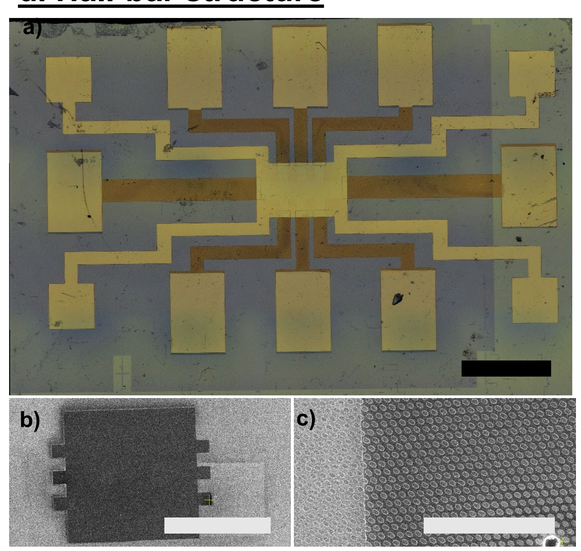
a) SEM image, scale bar 1μm**. b)** AFM scan and **c)** AFM line profile of patterned sub-5nm nanomembrane

c. Transfer of nanomembrane



a) Cross-section TEM, **b)** EDS mapping and **c)** EDS line profile of transferred Si nanomembrane on Si nanomembrane. SEM image of **d)** 90º twisted-bilayer Si nanomembrane before cleaning (scale bar 1μm), **e)** transferred nanomembrane on SiO_2 after cleaning at 50,000 magnification (scale bar 1μm) and **f)** 10,000 magnification (scale bar 5μm).

d. Hall-bar structure



a) Optical image of the hall-bar structure (scale bar 500μm)**.** SEM image of the patterned Si channel **b)** 100 magnification (scale bar 400μm) **c)** 10,000 magnification (scale bar 5um)

IV. FUTURE

- ❖ Refine transfer process to improve the transfer yield.
- ❖ Characterize the unique electrical and optical properties of generated artificial graphene.
- ❖ Fabricate the twistronic device structures and characterize their novel quantum phenomena.