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In-situ transfer of monolayer graphene fluoride flakes and study by scanning tunneling microscopy

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The production and characterization of graphene fluoride is of interest due to its retention of the layered structure of graphite and the introduction of a large (>3eV) band gap. Interest in graphene fluoride as an electronic material is extended by the possible reduction of multi-layer graphene fluoride to graphene[1,2]. In this work we demonstrate the exfoliation and characterization of predominantly monolayer graphene fluoride $(CF)_n$ flakes by an in-situ mechanical exfoliation process onto the Si(100) 2x1:H surface and investigate these features by scanning tunneling microscopy (STM). By a dry-contact transfer (DCT) process [3], monolayer graphene fluoride islands are transferred to the passivated silicon surface with negligible substrate contamination, as seen in earlier examples of graphene exfoliation [4]. This ultrahigh vacuum (UHV) compatible transfer enables UHV-STM imaging and electronic characterization of monolayer graphene fluoride islands (12 – 38 nm lateral dimension). The resulting topographic and spectroscopic data suggest local variations in fluorine coverage, which is manifested in variable topographic height, ranging from 5.3Å to 7.3Å (mean = 6.42 Å), and also in the small band gap measured in these islands when probed by scanning tunneling spectroscopy. However, the theoretically anticipated large gap (~3 eV) of graphene fluoride is demonstrated when weakly bound $(CF)_n$ islands are removed from the substrate to the STM tip. Subsequent transport through captured flakes exhibits band gaps of 2.8 – 3.2 eV.

For ex-situ investigation of transferred few-layer graphene fluoride, graphite fluoride powder is dispersed in N-Methylpyrrolidone (NMP), deposited onto silicon dioxide, and characterized by optical microscopy, atomic force microscopy (AFM), scanning electron microscopy (SEM) and energy-dispersive x-ray spectroscopy (EDX). We thereby verify the transfer of few-layer $(CF)_n$ from NMP and the decomposition and chemical modification of $(CF)_n$ under electron bombardment.

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