Semi Intercalated Graphene Ribbon Array on SiC By Fluorine Intercalation

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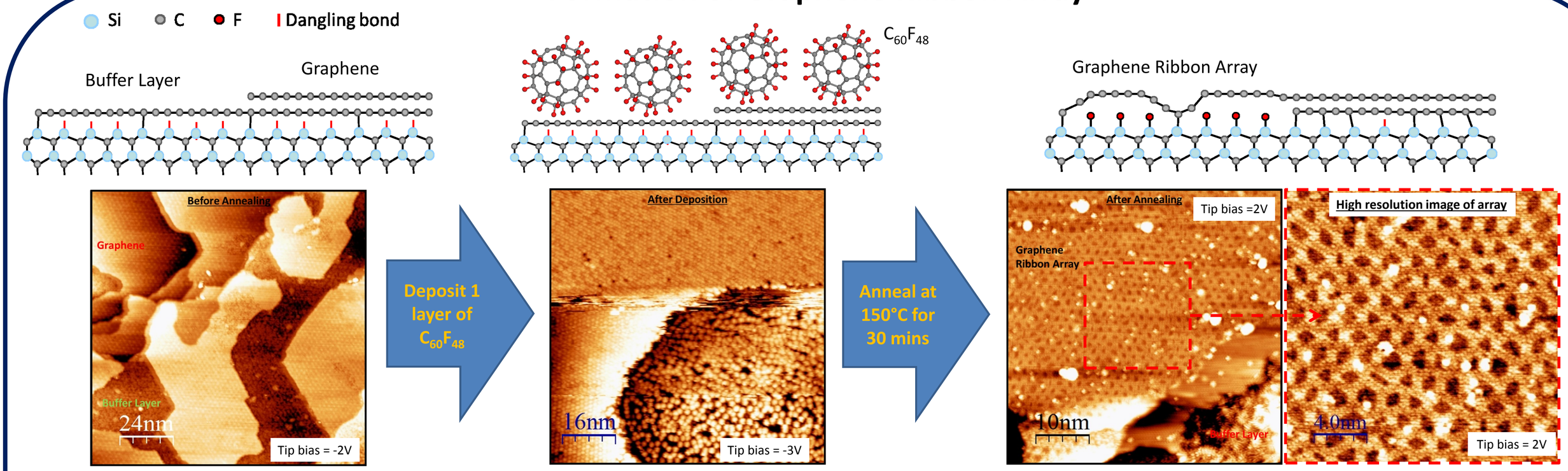
Epitaxial graphene on SiC(0001) is a promising route towards large scale fabrication of graphene devices but is limited by the presence of an interacting substrate which is mediated through the interfacial SiC(0001) 6√3 x 6√3 R 30°layer (buffer layer). Intercalation of the buffer layer to form quasi-freestanding epitaxial graphene has been performed to minimize this interaction. However, the intermediate stages of intercalation have not been reported in detail before. In this report, fluorine intercalation of the buffer layer was carried out using fluorinated fullerenes, C60F48, as a source of fluorine at moderate temperatures of 150°C. An intermediate stage was discovered and their properties were investigated using Low Temperature Scanning Tunnelling Microscopy (LT-STM) and Spectroscopy (STS). Motifs of nanostructures with quasi-periodicity (≈ 2nm) similar to that of the buffer layer were observed and the scattering patterns at their edges also coincide with those associated with graphene. STS measurements reveal that these nanostructures could possibly be a network of highly p-doped graphene ribbons with a band gap of about 250meV.

Introduction

Graphene, a single atomic layer of carbon, has attracted lots of attention in recent years due to its impressive electronic, optical, mechanical and thermal properties[1]. Those grown on hexagonal SiC(0001) wafers provide a means for large scale integration in existing device technology[2]. However, a limiting factor in the usage of such wafers is the high intrinsic electron doping and low electron mobility due to the buffer layer[3]. Removal of this buffer layer has been performed using fluroine[4] and other elements. However, in depth studies of the intermediate stages of intercalation have not been done. In this presentation, when fluorine from a molecular source is used to intercalate the buffer layer partially, a graphene ribbon array is observed and its associated physical and electronic properties are analysed.

Formation of Graphene Ribbon Array



SiC(0001) substrate with both monolayer graphene and buffer layer used in experiment.

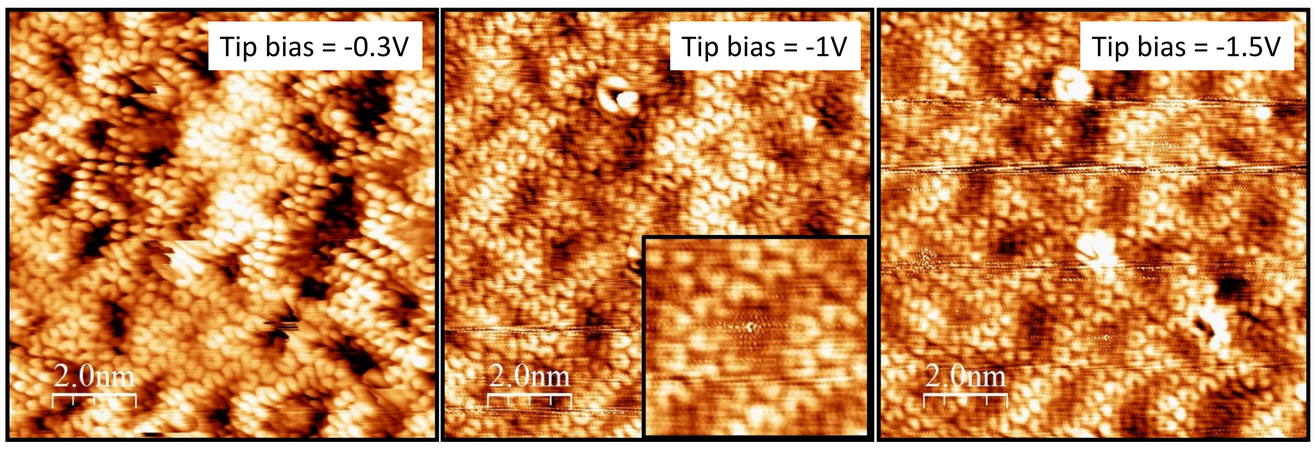
Fluorinated fullerenes, $C_{60}F_{48}$, are deposited at 110°C onto substrate kept at room temperature.

Non-close packed arrangement of molecules on buffer layer indicate higher adsorption energy compared to those adsorbed in closed pack manner on graphene.

Array of graphene ribbons are formed due to selective intercalation of fluorine in regions not bonded to silicon below.

Pre-existing monolayer graphene remains unaffected due to lower adsorption energy or graphene acting as barrier to fluorine entry.

Bias Dependent Topographical Changes

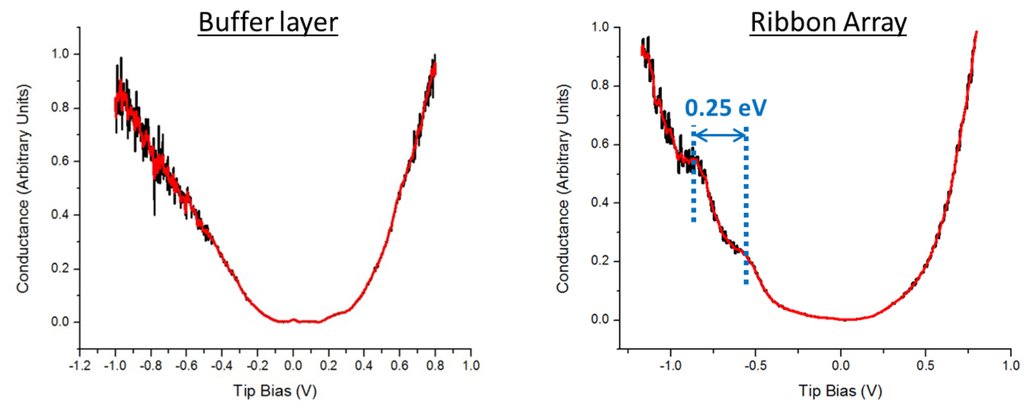


Bias dependent images indicate that apparent height of array is affected by bias and therefore not due to solely physical origins but rather combination of electronic and topographic.

Array most pronounced at low tip bias where subsurface SiC substrate or buffer electronic states contribution is negligible, indicative of graphenic nature of array.

Inset of middle panel shows scattering pattern at edges of the array resemble that observed at graphene edges.

STS measurements



STS measurements taken on buffer layer shows typical band gap about Fermi level.

STS on array indicates a band gap of 250 meV (peaks observed are due to maxima of valence band and minima of conduction band).

Dirac point approximated (by taking the mid-point of the peaks) at 0.7 eV above Fermi level.

Observations point towards a heavily p-doped graphene ribbon array with band gap of 250meV.

References

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