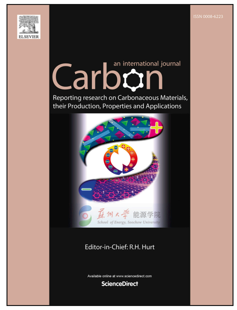


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PII: S0008-6223(16)30001-X

DOI: 10.1016/j.carbon.2016.01.001

Reference: CARBON 10632

To appear in: *Carbon*

Received Date: 18 November 2015

Revised Date: 24 December 2015

Accepted Date: 2 January 2016

# Thickness-Dependent Native Strain in Graphene Membranes Visualized by Raman Spectroscopy

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**Abstract**

Since graphene, a representative 2-dimensional crystal, has an extreme surface-to-volume ratio, its various material properties are known to be susceptible to various interactions with environment. Its high stretchability, in particular, allows graphene to conform well to external perturbation, which leads to modifications of its electronic, magnetic and chemical properties. In this work, we report a Raman spectroscopic strain metrology and visualize the native strain induced by the van der Waals interactions of mechanically exfoliated graphene of varying thickness with supporting silica substrates. Using freestanding graphene as a strain-free and charge-neutral reference, we quantified the resulting strain with a resolution of 0.02% and found that its spread decreases as increasing the number of layers finally reaching the detection limit for the thickness of ~30 layers. The spatially resolved strain maps revealed that the native strain is randomly distributed and that both of compression and expansion are also randomly generated. The current optical analysis can serve as a highly sensitive and efficient strain metrology tool for graphene samples in a wide range of thickness and can be extended to other 2-dimensional crystal systems.

## 1. Introduction

Two dimensional crystals represented by graphene has added significant fundamental scientific knowledge to our general understanding of low dimensional materials [1]. Whereas

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