



HAL
open science

Probing structural and electronic properties of h-BN by HRTEM and STM

Ouafi Mouhoub, Christian Ricolleau, Guillaume Wang, Hakim Amara, Amandine Andrieux - Ledier, Nelly Dorval, Frédéric Fossard, Pierre Lavenus, Jérôme Lagoute, van Dong Pham, et al.

► To cite this version:

Ouafi Mouhoub, Christian Ricolleau, Guillaume Wang, Hakim Amara, Amandine Andrieux - Ledier, et al.. Probing structural and electronic properties of h-BN by HRTEM and STM. 16th European Microscopy Congress, 2016, Lyon, France. pp.439, 10.1002/9783527808465.EMC2016.6944 . hal-01779710

HAL Id: hal-01779710

<https://hal.science/hal-01779710>

Submitted on 16 May 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Probing structural and electronic properties of h-BN by HRTEM and STM

Authors: Ouafi Mouhoub (1), Christian Ricolleau (2), Guillaume Wang (2), Hakim Amara (1), Amandine Andrieux (1), Nelly Dorval (3), Frédéric Fossard (1), Pierre Lavenus (3), Jerome Lagoute (2), Van Dong Pham (2), Pai Woei Wu (4), Annick Loiseau (1), Damien Alloyeau (2)

1. LEM, ONERA, Chatillon, FRANCE

2. MPQ, Paris Diderot, Paris, FRANCE

3. DMPH, ONERA, Chatillon, FRANCE

4. Department of physics, National Taiwan University, Taipei, TAIWAN

DOI: 10.1002/9783527808465.EMC2016.6944

Corresponding email: ouafi.mouhoub@onera.fr

Keywords: hexagonal boron nitride, aberration-corrected TEM, electron beam irradiation, Van Der Waals heterostructures

After the discovery of graphene and its consequences in the field of nanoscience and nanomaterials, there has been a growing interest in 2D materials and also their vertical stacking due to unique properties and potential applications.[1] For instance, it was shown the transport properties of exfoliated graphene supported by hexagonal boron nitride (h-BN) could approach the intrinsic graphene limits.[2] Nevertheless, studying the structural properties of 2D materials and 2D heterostructures is crucial to understand their physical and chemical properties. Our motivations have been to exploit state of the art aberration-corrected high resolution transmission electron microscopy (HRTEM) and scanning tunneling microscopy (STM) to study the structure and electronic properties of graphene (G), h-BN and G/h-BN heterostructures.

HRTEM analyses were conducted with a JEOL ARM microscope equipped together with a cold FEG, an aberration corrector for the objective lens and a One view camera (Gatan). Notably, we used high-speed atomic-scale imaging to study with unprecedented dynamics (up to 25 fps) the nucleation and growth mechanisms of triangular holes in h-BN under beam irradiation (Figure 1). The direct observation of B and N atom sputtering and surface reconstruction processes allow understanding how the triangular shape and orientation of holes are maintained during the growth. Interestingly, by studying the effects of the electron dose and the number of BN layers, we demonstrate that these atomic-scale processes are simultaneously driven by kinetic and thermodynamic effects. Further works are in progress to study the stability of h-BN/G stacking under electron-beam irradiation.

STM analyses were carried out with low temperature STM at 4 K, on 2D heterostructures that consist in a few layers of graphene doped with nitrogen on thick exfoliated flakes of BN deposited on SiO₂. Remarkably, we show that STM allows identifying and characterizing ionization defects within the BN flakes below the graphene layers (Figure 2). This study opens new avenues to probe the electronic interactions between this two stacked materials.

References:

[1] Geim & al., Nature, 499, 419 (2013)

[2] J. M. Xue & al., Nature Mater, 10, 282 (2011)

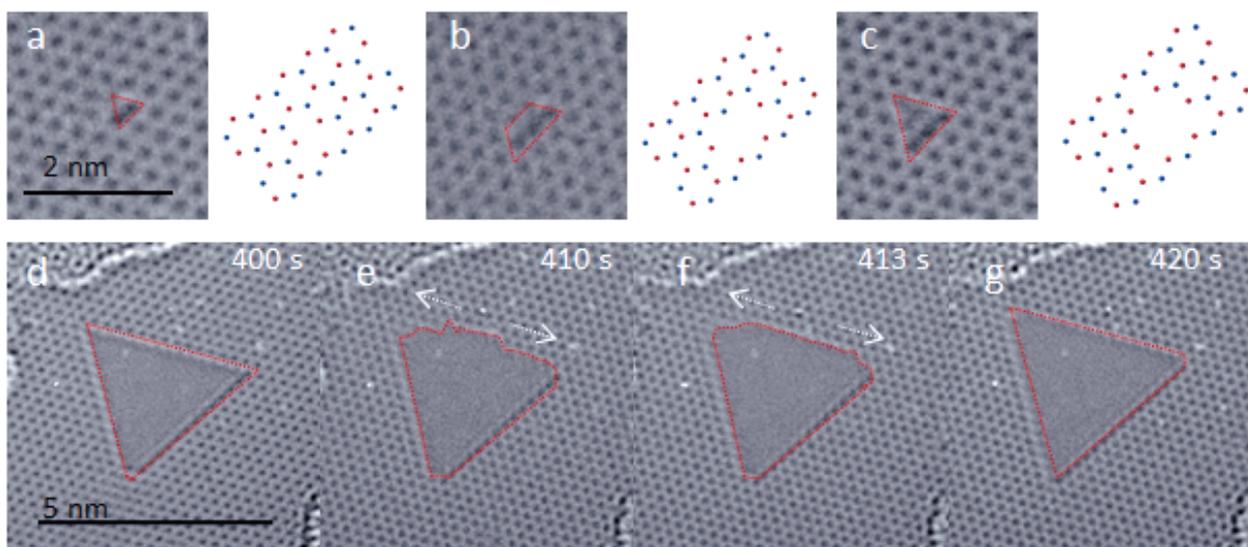


Figure 1: HRTEM images showing the nucleation (a-c) and the growth mechanisms (d-g) of a triangular hole in monolayer hexagonal boron nitride under electron beam irradiation.

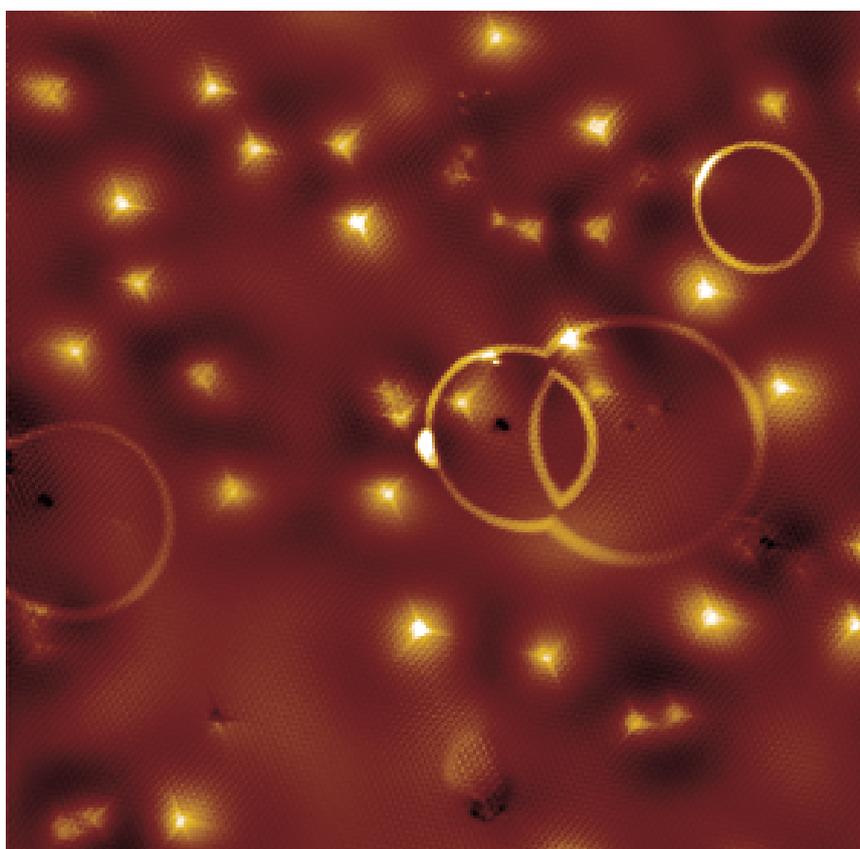


Figure 2: STM conductance map image (50 x 50 nm, 0.5 V, 50 pA) showing ionization defects within a nitrogen doped graphene / BN heterostructures. The bright triangular shaped dots are nitrogen atoms in substitution inside the graphene capping layer, bright rings are the ionization rings which seem to come from defects buried within the h-BN.