Twisted graphene formation mechanism on graphene/SiC template

Osaka University [1], NTT Basic Research Laboratories [2]

°Y. Yao[1], T. Inoue[1], R. Negishi[1*], M. Takamura[2], Y. Taniyasu[2] and Y. Kobayashi[1]

E-mail: yaoyao@ap.eng.osaka-u.ac.jp

[Introduction] Twisted few layer graphene (FLG) has recently attracted great attention due to the appearance of the exotic electrical properties [1]. In previous study, we reported that the FLG was synthesized by overlayer growth of graphene on a monolayer graphene template using a chemical vapor deposition (CVD) method. We found that moiré pattern appears in the lattice structure of the grown graphene 2-dimensional (2D) island and the grown 2D graphene islands have the random twisted angles. Coalescence process of graphene island with various twist angles was indicated by temperature dependence of graphene island size [2]. In this study, to understand the growth mechanism of twisted FLG, we further examined the dependence of pressure systematically. With detail analysis of graphene islands grown on graphene template, we proposed the vertical and lateral morphology model.

[Experiments] The 2D graphene islands with a monolayer step height were grown by CVD with ethanol as a carbon feedstock on continuously oriented monolayer graphene synthesized on silicon carbide substrate. The growth was carried out in an infrared heating furnace at the partial pressure from 7 to 17.5 Pa by tuning argon flow rate. The atomic force and scanning tunneling microscopes (AFM/STM) were used to evaluate the surface morphology.

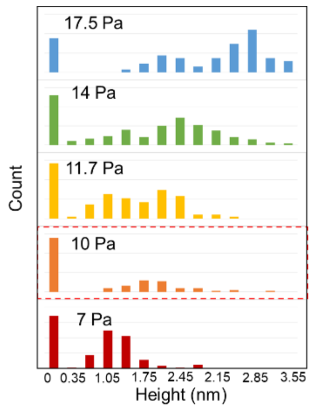

Fig. 1 Statistical data from AFM images with vertical morphology in graphene islands for pressure dependence.

[Results and discussion] Twisted graphene is created through CVD at high temperature and low pressure on continuous monolayer epitaxial graphene template. Growth pressure, temperature, and time are varied independently to understand how surface features and morphology affect graphene formation. On the basis of previous research, data from AFM determine the optimal conditions at 1400℃, 10 Pa (Fig. 1) for the further analysis of growth features. On the route toward a graphene island, various growth features, such as two-dimensional nucleation and growth, three-dimensional nucleation and growth, and coalescence of growing islands are observed and analyzed. The constant current images of STM determine the surface structure and growth features. Moiré pattern in an STM image with different lattice structure indicates the diverse twisted angles (Fig.2). Based on the analysis of STM/AFM images, we propose the growth mechanism shown in Fig. 2. It is typically shown in two-dimensional nucleation that graphene islands nucleate very closely. Then, graphene islands gradually approach to each other in lateral directions as they grow. As the surface energy of graphene changes, more carbon atoms are precipitated to form additional graphene islands, which are divided by boundaries into several domains with various twisted angles.

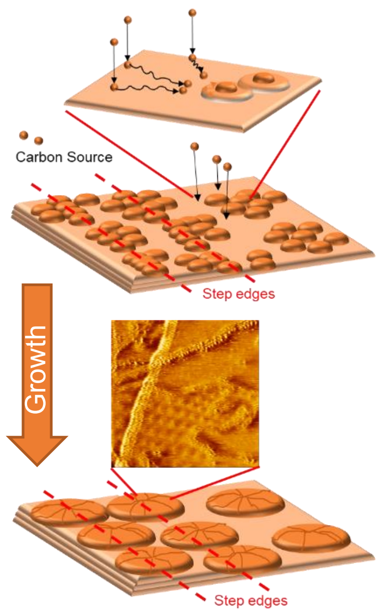

Fig. 2 Two-dimensional nucleation and early growth stage and late growth

謝辞：本研究の一部は科研費の援助を受けて実施しました。

References: [1] R. Negishi et al., Physical Status Solidi B **257**, 1900437 (2020).
[2] Y. Yao et al., 2020 年第 81 回応用物理学会秋季学術講演会 9a-Z29-8

———————————

*Present affiliation: Toyo University