Probing formation of graphene on silicon carbide surface by metal decoration

Poon S. W., Chen W., Tok E. S., Wee A. T. S.*

Department of Physics, Faculty of Science, National University of Singapore, 2 Science Drive 3, Singapore 117542.
*e-mail: phyweets@nus.edu.sg

Introduction

Graphene:-

- single layer
- highly 2D
- honeycomb
- \( sp^2 \)

Its carrier exhibits unique Dirac fermion properties, making graphene as potential material for next generation nanoelectronics.

However, properties affected by scattering at steps and grain boundaries. Understanding of graphene growth is vital to control and improve epitaxy quality.

Objective

To probe the growth mechanism of graphene on carbon-rich phase of silicon carbide (SiC).

Methods

6H-SiC(0001) (Si terminated)

volatile SiO\(_x\)

\( 1000^\circ C \)

\( 1100^\circ C \)

C-rich (6\( \sqrt{3} \times 6\sqrt{3} \))R30\(^\circ \)

\( >1200^\circ C \)

UHV system

Graphene

- Co is evaporated to identify and distinguish \( 6\sqrt{3} \) and graphene.

Results & Discussion

(I) Growth of graphene

- Figure 1a shows a surface with \( 6\sqrt{3} \) and graphene co-exist is not easily differentiable, hence difficult to probe graphene formation.

(II) Kinetic analysis

- Surface evolution at different \( T \) and time are shown in Fig. 2a-c and percentage of area covered with graphene is plotted in Fig. 2d.

Figure 1. STM images of (a) \( 6\sqrt{3} \) & graphene (G) co-exist but not differentiable, (b) Co is used to identify the phases, (c) G starts from step edges, (d) incomplete graphene growth.

- After Co deposition, they are distinguishable due to different adsorption of Co, with high Co density on \( 6\sqrt{3} \) and low density on graphene (Fig. 1b).

Figure 2. Distribution of \( 6\sqrt{3} \) and graphene at different temperatures (T) (a) \( 1205^\circ C \), (b) \( 1260^\circ C \) and (c) \( 1305^\circ C \); (d) area of graphene (%) as a function of annealing time and T; (e) Arrhenius plot of rate constant, \( k_a \) extracted from (d).

- Each plot gives a \( T \)-dependant rate constant, \( k_a \) and analysis according to our model (not shown here) produced an Arrhenius plot with barrier of \( 3.0 \pm 0.4 \text{eV} \), close to our prediction that breaking C-C or C-Si bonding energy is the overall rate-limiting step in the transformation (Fig. 2e).

Conclusions

- Graphene growth can be followed systematically using Co as tracer.
- Since transformation starts mainly at step edges, well-ordered graphene with few domain boundaries for device application can only be obtained from high quality polished on-orientation SiC.

Literature cited

Berger et al. (2006) Science 312, 1191.