

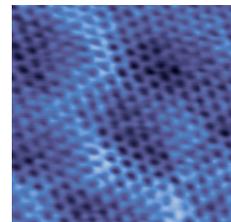
Probing formation of graphene on silicon carbide surface by metal decoration



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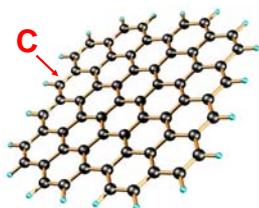
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Introduction

Graphene:-



- single layer
- highly 2D
- honeycomb
- sp^2

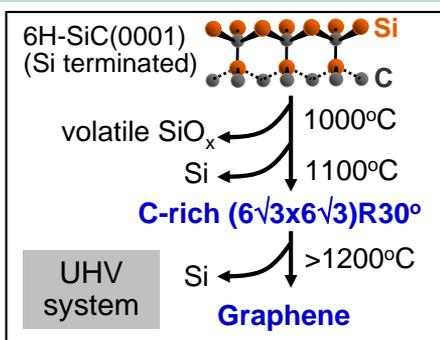
Its carrier exhibits unique Dirac fermion properties, making graphene as potential material for next generation nanoelectronics.

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



- 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.

- 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).

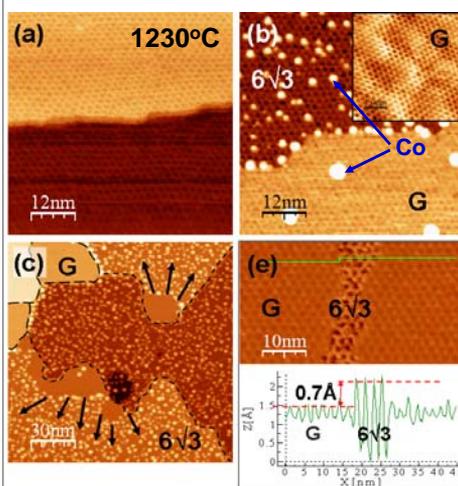


Figure 1. STM images of (a) $6\sqrt{3}$ & graphene (G) co-exist but not differentiable, (b) Co is used to identify the phases, (c) G starts from step edges, (d) incomplete graphene growth.

- Our results show that:-
(i) Graphene preferentially starts at step edges (Fig. 1c) (more dangling bonds, more open structure for Si desorption).
(ii) Growth consumes C atoms supplied *via* decomposition of $6\sqrt{3}$ (from reduced height of graphene terrace in line profile of Fig. 1d).
(iii) A new $6\sqrt{3}$ phase form beneath graphene due to continuous Si desorption, act as buffer layer for graphene from underlying substrate.

(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.

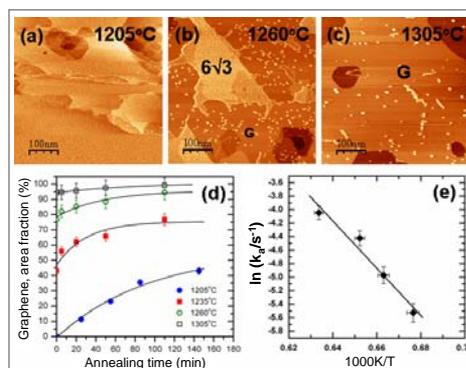


Figure 2. Distribution of $6\sqrt{3}$ and graphene at different temperatures (T) (a) 1205°C, (b) 1260°C and (c) 1305°C; (d) area of graphene (%) as a function of annealing time and T; (e) Arrhenius plot of rate constant, k_a extracted from (d).

- 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

- Novoselov et al. (2005) *Nature* **438**, 197.
Zhang et al. (2005) *Nature* **438**, 201.
Berger et al. (2006) *Science* **312**, 1191.
Chen et al. (2005) *Surf. Sci.* **596**, 176.
Chen et al. (2004) *Appl. Phys. Lett.* **84**, 281.
Poon et al. (2006) *Phys. Chem. Chem. Phys.* **8**, 3326.
Ong et al. (2006) *Phys. Rev. B* **73**, 045330.