Real-time monitoring of graphene CVD growth using ultraviolet reflection

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Real-time monitoring is a powerful tool for clarifying growth mechanisms and controlling a material's growth. In the case of graphene growth by chemical vapour deposition (CVD), real-time monitoring has been demonstrated by using environmental scanning election microscopy (SEM) and radiation microscopy [1, 2], but they are available only under limited growth conditions and setups, such as a high-vacuum environment and a cold-wall chamber. Here, we report real-time optical reflection observation with an ultraviolet (UV) light source as a way to monitor graphene growth on a Cu substrate during CVD. Our real-time observation is available for the conventional thermal CVD setup with a hot-wall chamber (over 1000˚C) near atmospheric pressure. Considering the optical reflectance of graphene on Cu and the thermal radiation energy at the growth temperature (around 1050˚C), we choose monitoring wavelengths below 600 nm for clear observation of graphene growth on Cu during CVD. The figure shows images observed during graphene CVD growth at 1060°C using an illumination light source with wavelengths of (a) 265 and (b) 365 nm. As examples, some of the graphene domains are indicated by dotted lines. As the growth progresses, it is clearly observed that graphene domains nucleated on the Cu and their size increased. The formation of graphene domains was also confirmed by ex-situ Raman spectroscopy. The image contrast of graphene on Cu varies with monitoring wavelengths because of their wavelength-dependent refractive index. In particular, the refractive index of graphene largely changes at around 270 nm due to an interband optical transition at the M points in Brillouin zone. Consequently, the contrast inverts: graphene domains are observed to be bright at 265 nm and dark at 365 nm with respect to the Cu surface. We also observed in real time that the nucleation and growth process of graphene changes depending on the CVD conditions. Our method will be helpful in deepening our understanding of the growth mechanism and achieving real-time growth control for high-quality graphene.

REFERENCES

[1] Z. Wang et al., ACS Nano 9 (2015) 1560.
[2] T. Terasawa et al., Nat. Commun. 6 (2015) 6834.

FIGURES

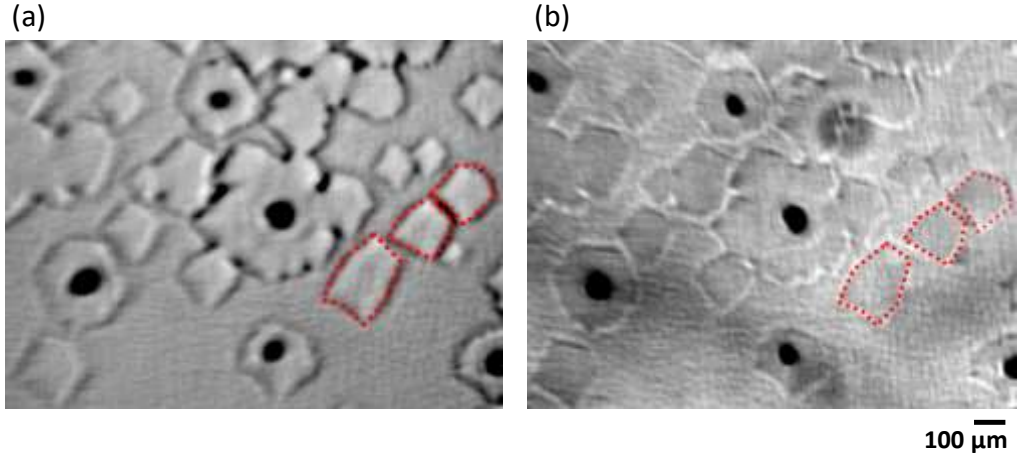

Figure : Reflection optical micrographs of graphene on Cu during CVD growth at 1060˚C with illumination light having peak wavelengths of (a) 265 and (b) 365 nm.