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Supporting Information

Continuous Graphene Films Synthesized at Low Temperatures by Introducing Coronene as Nucleation Seeds

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1. Graphene growth from naphthalene

In this report, we achieved continuous graphene films at various temperatures (300 ^{o}C-600 ^{o}C) by using naphthalene due to its thermal instability and cyclobenzene structure.[1] The modified chemical vapor deposition (CVD) growth equipment is shown in Fig. S1a. Fig. S1b presents the result of thermo gravimetric analysis (TGA) for weight loss of naphthalene during sublimation in Ar.

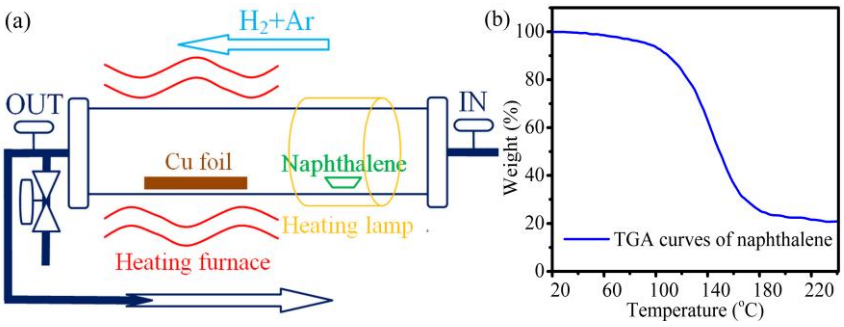

Fig. S1 (a) The modified CVD growth equipment for synthesis of graphene by Naphthalene; (b) The TGA curve of naphthalene in Ar at a heating rate of 10 ^{o}C/min.

2. Optical performance of graphene synthesized by seed assistant procedure

Light transmittance and optical micrographs of the transferred graphene films on quartz substrates synthesized from 300-600 ^{o}C are shown in Fig. S2. The 96.1-96.9% transmittance ratio and the continuous optical images confirm the synthesis of uniform single-layer graphene films, which is consistent with the Raman results (see Fig. 1b in manuscript).

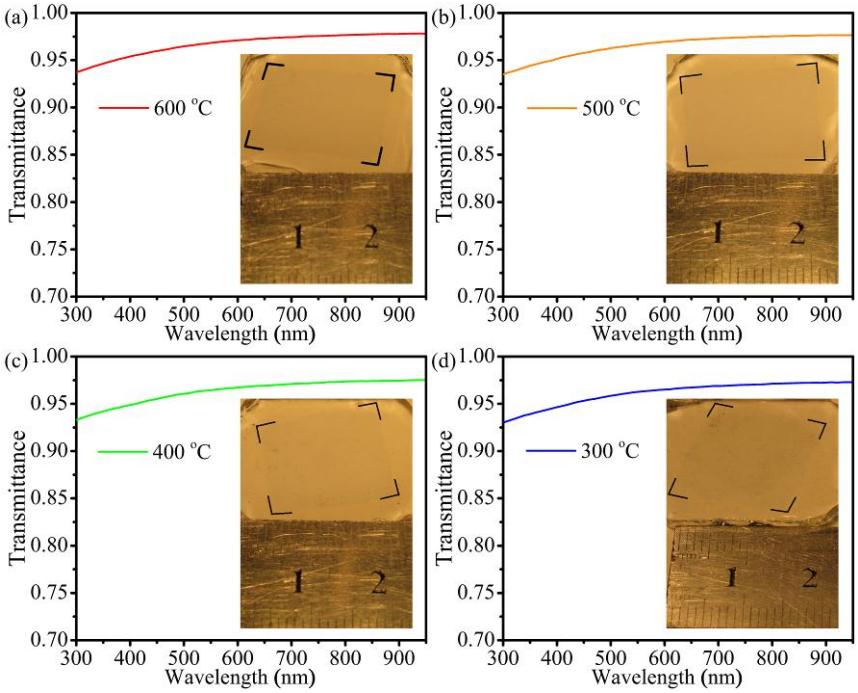

Fig. S2 Optical images and transmittance of large-area graphene layers transferred on quartz synthesized at (a) 600 °C; (b) 500 °C; (c) 400 °C and (d) 300 °C.

3. Critical T_n for initiating nucleation of graphene

To well illustrate the nucleation optimization, graphene samples synthesized with and without coronene seeds were fabricated at 600 °C by using naphthalene precursor for comparison. For samples without introducing coronene seeds, higher heating temperature of naphthalene (T_n) was essential to achieve supersaturation of activated carbon related radicals for overcoming the nucleation energy barrier as the blue heating curve in Fig. S3a. When coronene seeds were deposited on Cu surface, lower concentration of carbon related radicals was required to initiate the nucleation as the red heating curve in Fig. S3a. At last, graphene grains eventually connect with each other and form continuous polycrystalline graphene films.

The critical T_n for nucleation threshold at different growth temperatures were studied as shown in Fig. S3b. When coronene seeds are introduced on Cu surface, it was found that lower T_n is required for the nucleation (shown in Fig. S3b). Meanwhile, it was also found that higher T_n was demanded to provide larger supersaturation of carbon related radicals and initiate the nucleation at lower growth temperature (see in Fig. S3b). It is due to the reduced catalysis effect of Cu with the decrease of growth temperature, which is participator for promoting the dehydrogenation and activation of cyclobenzene related molecules (see in Fig. S3b).

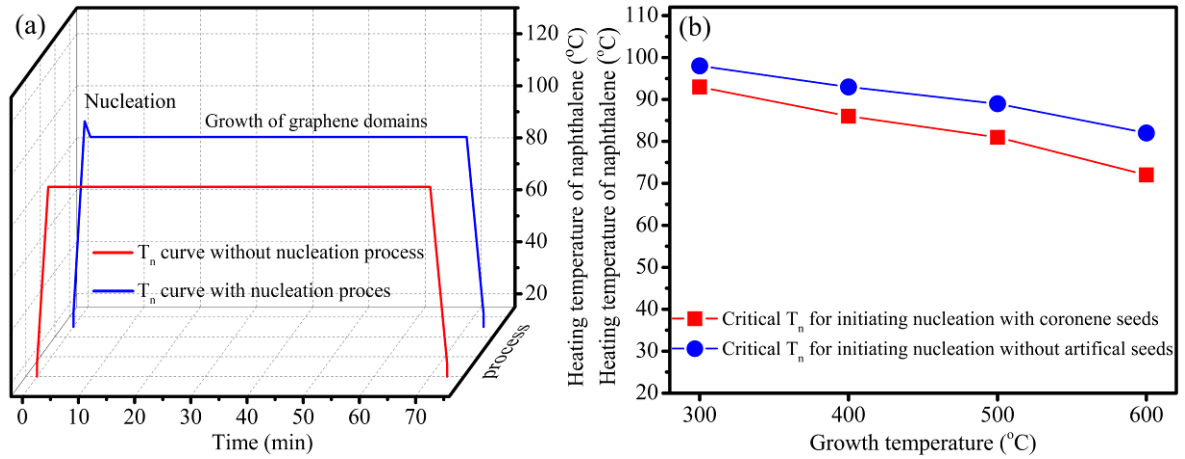

Fig. S3 (a) Heating temperature curves of naphthalene for graphene growth on polished Cu surface with or without coronene seeds at 600 ^{o}C; (b) Critical T_n for initiating nucleation of graphene at different growth temperatures.

4. Graphene synthesized without introducing coronene seeds

Graphene synthesized without seed assistant procedure at low temperature always induced the growth of relatively small flaks with many multilayer domains (see in Fig. S4). With the decrease of growth temperature, the reduced catalysis effect of Cu and motions of carbon related radicals on Cu foils induce the local aggregation of carbon species. The non-uniform accumulation of reactant promotes un-controlled nucleation of second layer and even multilayers with more defects.

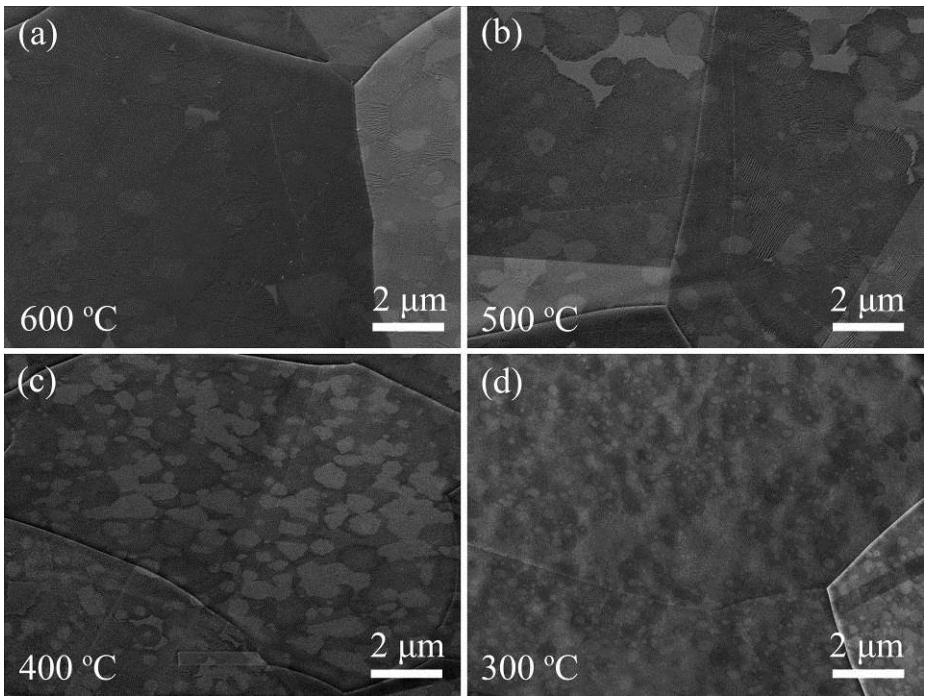

Fig. S4 SEM images of graphene synthesized at (a) 600 ^{o}C, (b) 500 ^{o}C, (c) 400 ^{o}C and (d) 300 ^{o}C without introducing coronene seeds.

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5. Transfer characteristics of graphene synthesized with and without seed assistant procedure

The electronic properties of samples synthesized with and without coronene seeds at different growth temperature were investigated for comparison (as shown in Fig. S5). The carrier mobility of graphene films decreased with the reduction of growth temperature. This may result from the increased density of grain boundaries and defects in graphene films. The obtained channel field effect mobility of graphene fabricated by introducing coronene seeds are better than that of graphene fabricated by normal process, suggesting that the as-synthesized graphene films are of reasonable quality. It indicates that coronene seed aided growth process could induce regular nucleation and uniform graphene grains, which significantly improve the electrical performance of the continuous graphene films.

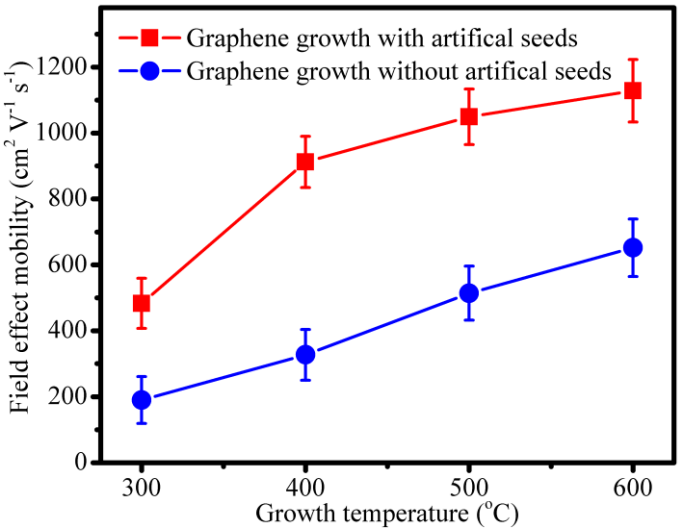

Fig. S5 The electronic properties of samples synthesized with and without coronene seeds at various growth temperature.

Reference

1 O. Kobayashi, D. Uraguchi and T. Yamakawa, *Org. Lett.*, 2009, **11**, 2679.