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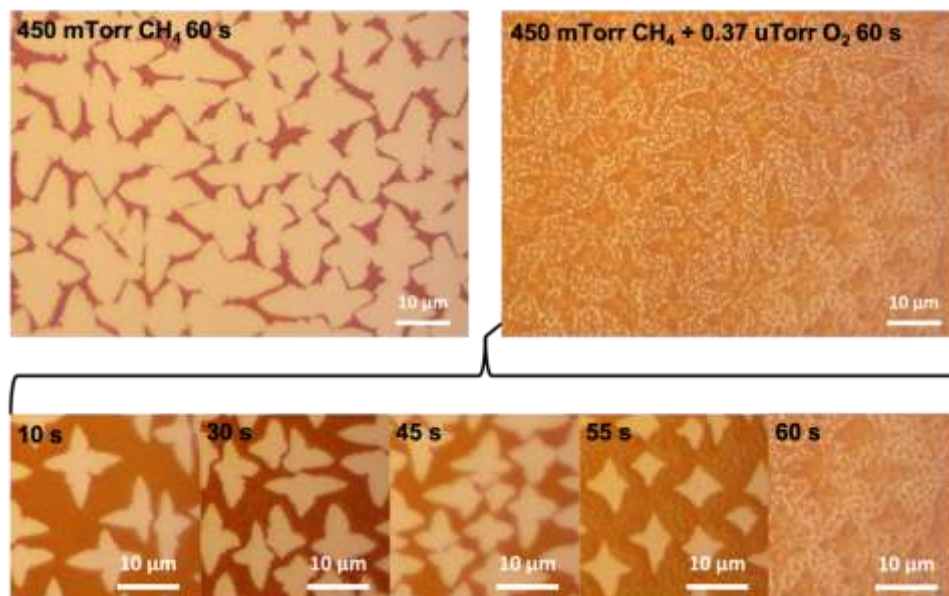
## Influence of trace oxygen species on chemical vapor deposition (CVD) graphene growth kinetics

Deliberate oxidation of copper substrates prior to CVD graphene growth has proven to significantly alter the nucleation density, grain size, and defect concentration of the resulting film [1]. Here we develop a model to discuss the role of part-per-million oxygen in gas feedstocks on graphene growth kinetics. By eliminating trace oxygen in the gas feedstock and furnace atmosphere, we obtain fast, high-quality growth without the reliance of hydrogen to balance oxygen species [2]. We demonstrate the formation of a pinhole-free, continuous graphene within 1 minute due to the lack of oxygen impurities. The  $O_2/H_2$  ratio was explored to understand the balance between grain growth and oxygen-based etching. This study sets the maximum oxygen concentration with respect to hydrogen to facilitate fast, reproducible graphene growth. Our findings highlight the competitive nature of absorbed methane intermediate species as carbon precursors and trace surface oxide as the growth inhibitor and set the limit between impurities limited growth and methane adsorption-dissociation limited growth. We assert that CVD graphene growth in standard ultra-high purity gas feedstock without downstream purification falls within the impurities limited growth regime, thus is held at the mercy of oxidizing etching reactions.

### References

- [1] Choubak, Saman, et al. The Journal of Physical Chemistry C 118.37 (2014): 21532-21540
- [2] Choubak, Saman, et al. The Journal of Physical Chemistry Letters 4.7 (2013): 1100-1103

### Figures



**Figure 1:** Time evolution of CVD graphene etching in a 0.77 ppm oxygen environment.