

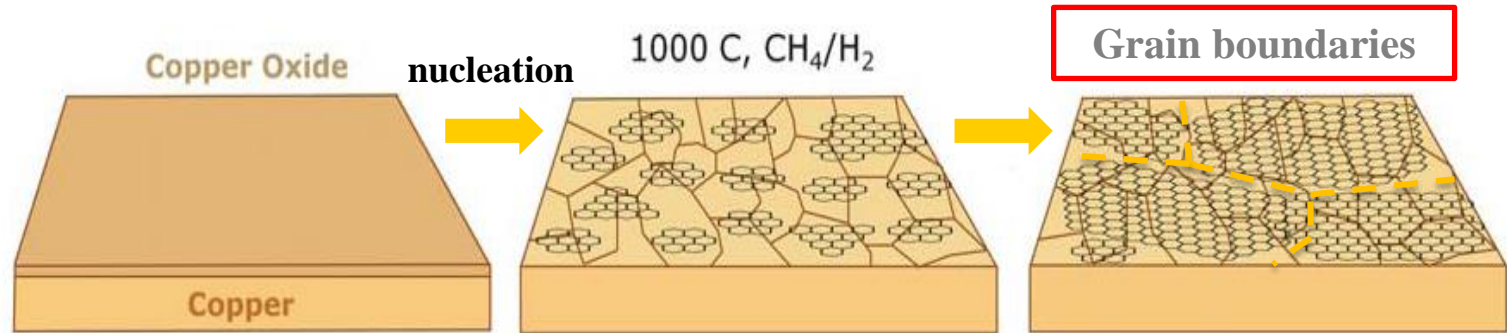
Gas transport controlled graphene synthesis via jig gap: Nucleation and growth study

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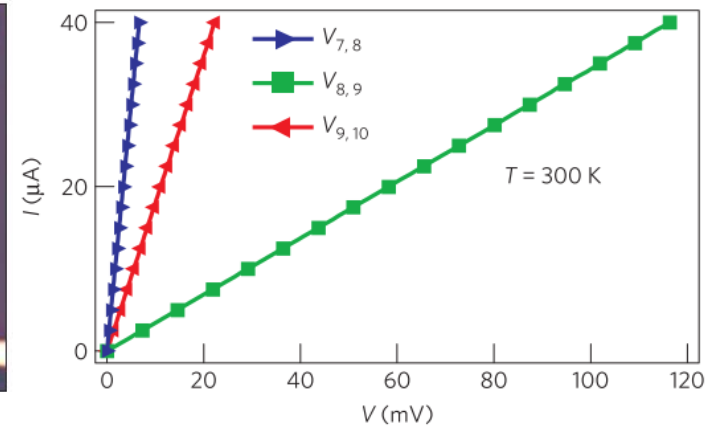
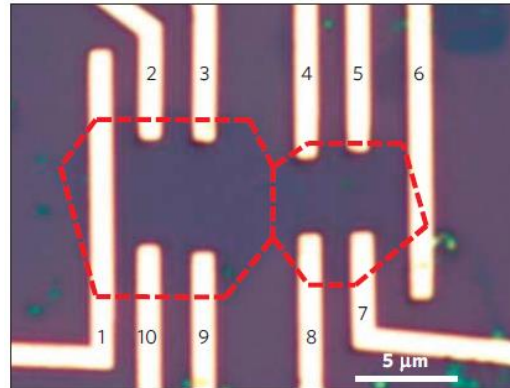
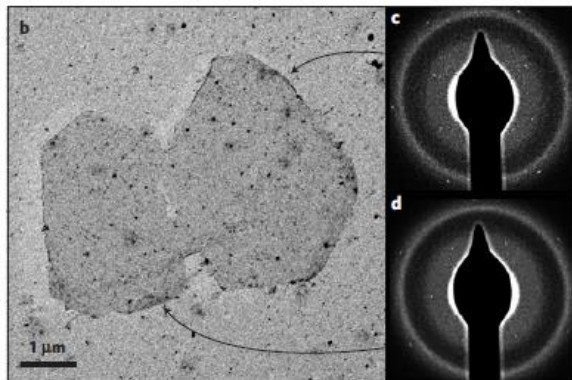
Polycrystalline nature of graphene growth

Random nucleation in graphene CVD



C. Mattevi, *et al.*, *J. Mater. Chem.* **21**, 3324 (2011)

Electrical properties in polycrystalline graphene



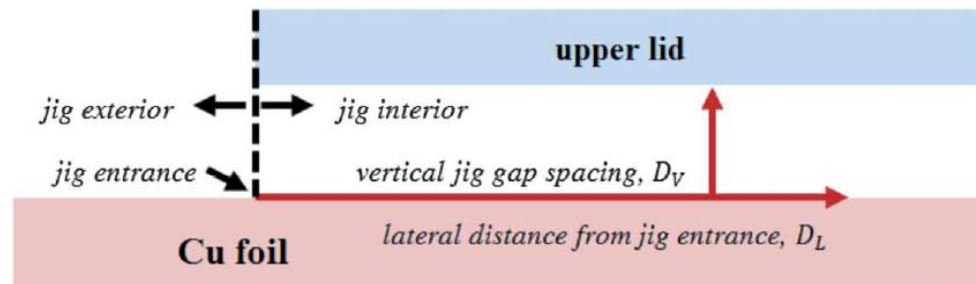
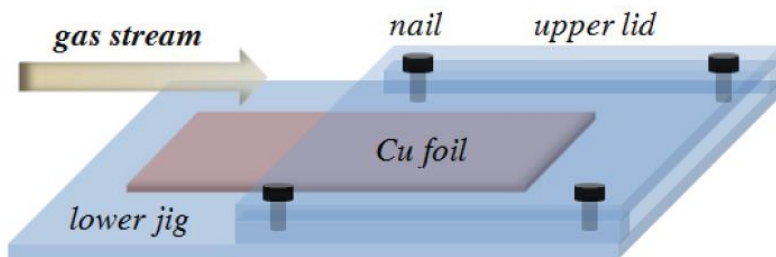
Q. Yu *et al.*, *Nature Mater.* **10**, 443 (2011)



Understanding on growth mechanism and controlling method is required

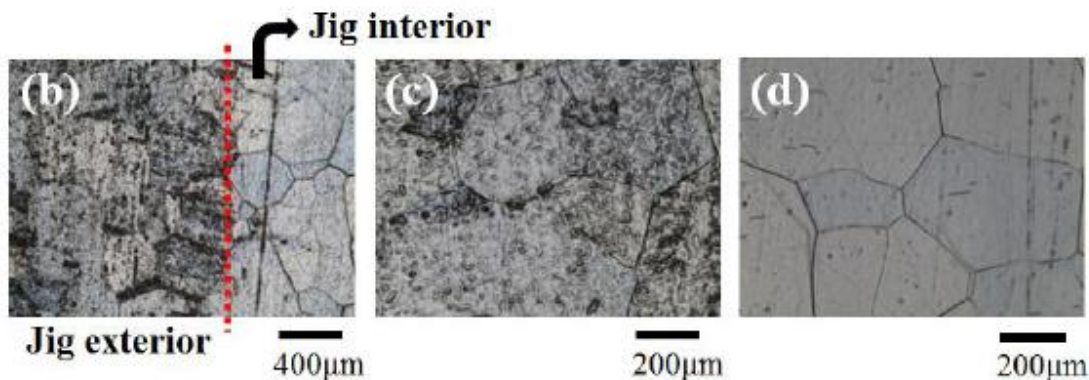
Jig concept for gas transport study

- Graphene CVD appears relatively simple, but obtaining a high quality graphene is another issue.
- Both the kinetics on nucleation and growth should be well understood and controlled.

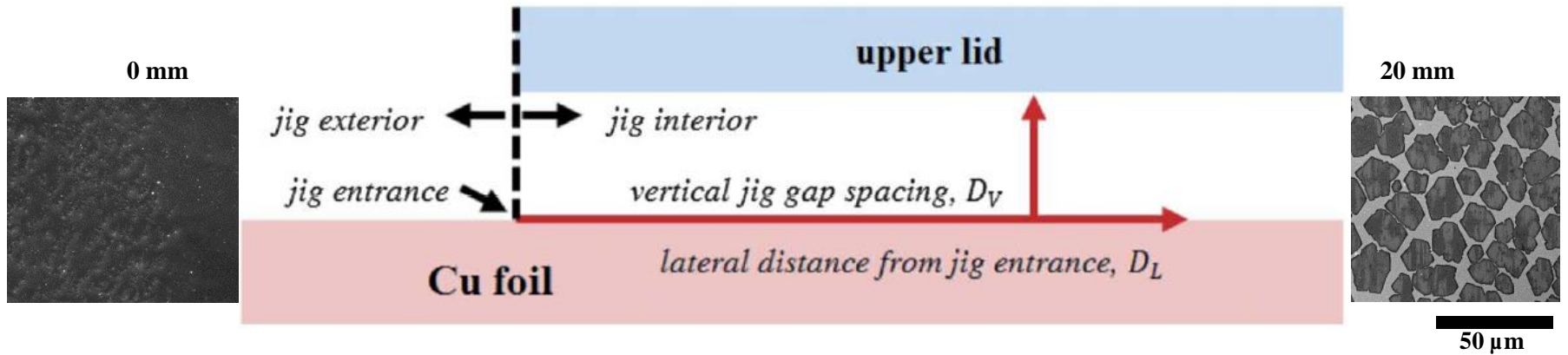


Jig is an excellent tool to observe gas transport effect in graphene growth by controlling boundary layer thickness in CVD system. Gas conductance control was observed directly.

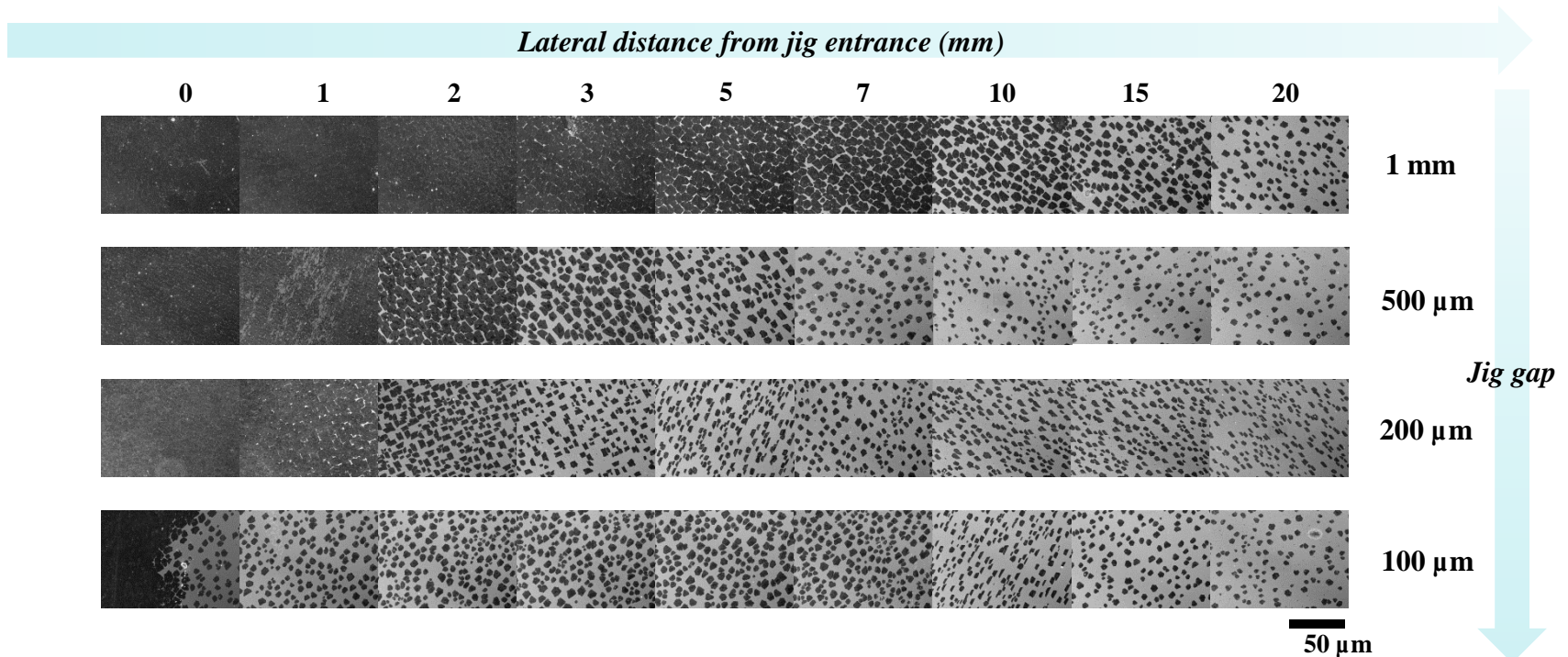
Jig effect on pre-annealing: Reduction of copper sublimation



Effect of jig gap on graphene growth

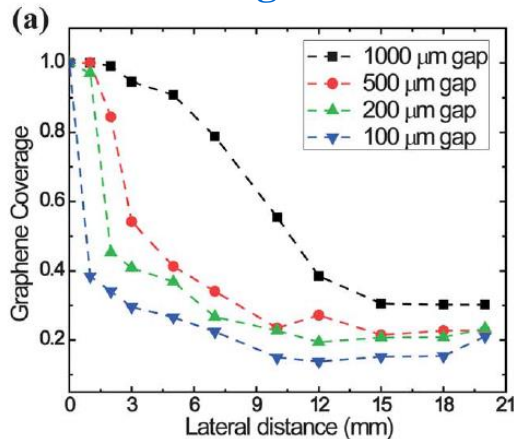


Nucleation and growth behavior in jig gap

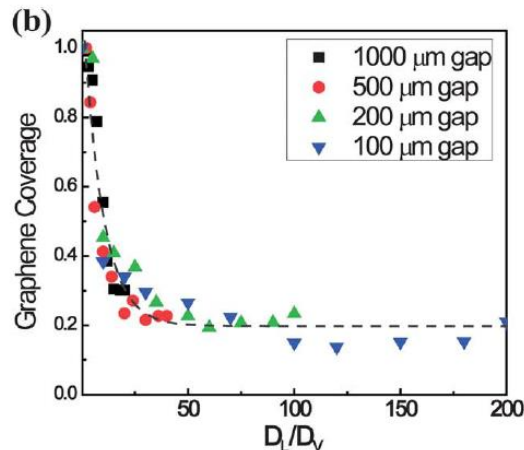


Analysis on nucleation and growth

Areal coverage vs. distance



Normalization



$$C = k \frac{A}{L}$$

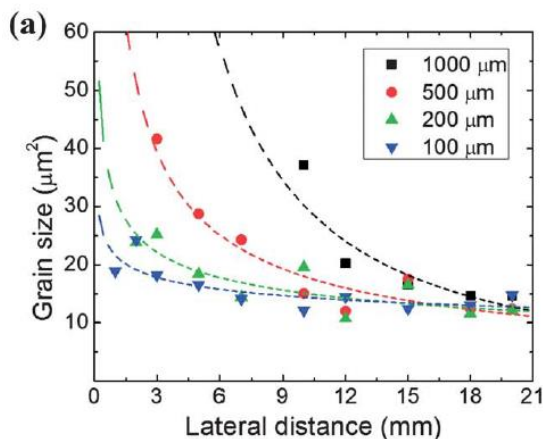
$$\approx k' \frac{D_L}{D_V}$$

C : gas conductance
 A : area
 L : length
 k/k' : constant
 D_L : lateral distance
 D_V : vertical distance

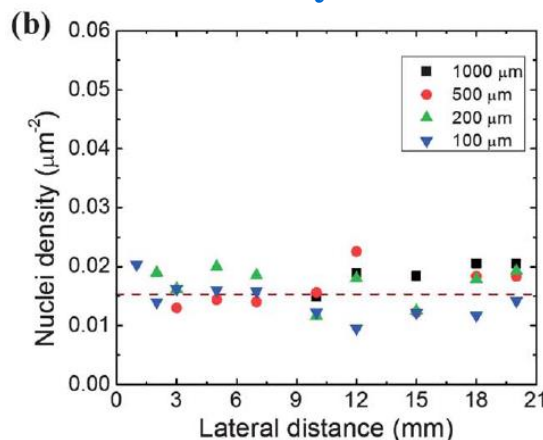


Gas conductance was successfully controlled by manipulating jig gap. Universal conductance parameter D_L/D_V governs graphene coverage.

Grain size variation



Nuclei density variation



$$N^* = n_s \exp\left(-\frac{\Delta G^*}{kT}\right)$$

N^* : equilibrium concentration of critical nuclei
 n_s : density of nucleation site
 ΔG^* : function of degree of supersaturation
 k : Boltzmann constant



Variation of gas conductance via jig gap controls grain size of graphene, but nuclei density was independent of gas transport control.

- Reduction of copper surface : static vapor condition limits the sublimation and re-deposition of Cu which make Cu surface smoother
- Morphology of graphene grain : because of carbon source depletion and continuous etching of hydrogen, graphene grain shape shifted from dendritic to polygon
- Coverage of graphene : coverage of graphene show general behavior to the parameter, D_L/D_V , which is gas conductance
- Grain size and nuclei density of graphene : grain size of graphene is the function of gas conductance whereas nuclei density is not. The nuclei density itself considered to related with the nucleation site, heterogeneous nucleation behavior of graphene.