Effect of Temperature on the Growth of Single Crystalline Monolayer Graphene by Chemical Vapor Deposition (CVD)

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Abstract

The ever increasing interest in graphene properties and its applications[1,2] has motivated the controlled growth of high-quality graphene[3] and fabrication of graphene-based devices[2]. The growth of graphene via CVD using metal catalysts depends on both the intrinsic properties of the metal catalysts and the growth parameters[4]. Here we demonstrate that the structure of single layer graphene flakes grown on a copper substrate by low pressure CVD depends dramatically on the furnace temperature, within a few tens of degrees Celsius. Optical microscope analysis of as-grown and transferred graphene onto SiO_2/Si shows that growth at 1000 ^{0}C results in dendritic shapes (Figure a) while growth at 1040 ^{0}C gives a compact graphene flake (Figure b). The low temperature growth was extended over a long time (1 hour) in order to check if there was a change in the structure towards a compact flake as the one in Figure b, which was obtained after just 10 minutes of growth time at 1040 ^{0}C. However, the size of the dendrites increased without merging. Although still poorly understood, the dendritic growth may be due to the poor smoothening of the copper at the lower annealing temperatures and to the low carbon attachment/detachment kinetics at the graphene growth fronts.
We have characterized the charge and spin transport properties of the graphene grown at low temperatures. We have fabricated non-local spin valve devices with 3 μm graphene channel length and found a spin life time of 0.2 ns and spin diffusion length of 2.5 μm at room temperature. The mobility of the device was of 1000 cm^2/Vs, which is typical for CVD grown graphene on SiO_2/Si. Future work will focus on comparing these results with the spintronic performance of graphene grown at higher temperatures.

References

1. Geim, A. K. & Novoselov, K. S. *Nat. Mater.* 6 (2007) 183–191.
2. Kamalakar, V. M., Groenveld, C., Dankert, A. & Dash, S. P. *Nat. Commun.* 6, (2015) 6766.
3. Shin, Y. C. & Kong, J. *Carbon* 59, (2013) 439–447.
4. Chen, C.-C. *et al. Chem. Mater.* 27, (2015) 6249–6258.

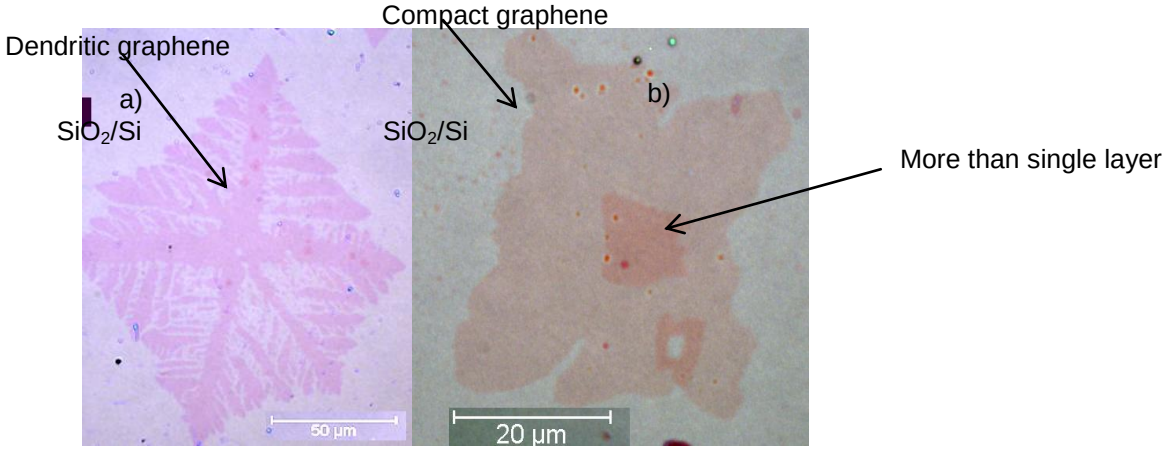

Figure: a) low temperature and b) high temperature grown graphene on SiO_2/Si substrate