

# Low Temperature direct growth of graphene on germanium substrate

**Mariam Ali Almahri**

Yu-Cheng Chiou, Senamees Khrais, Matteo Chiesa

Khalifa University for Science and Technology,  
Abu Dhabi, United Arab Emirates

[mchiesa@masdar.ac.ae](mailto:mchiesa@masdar.ac.ae)

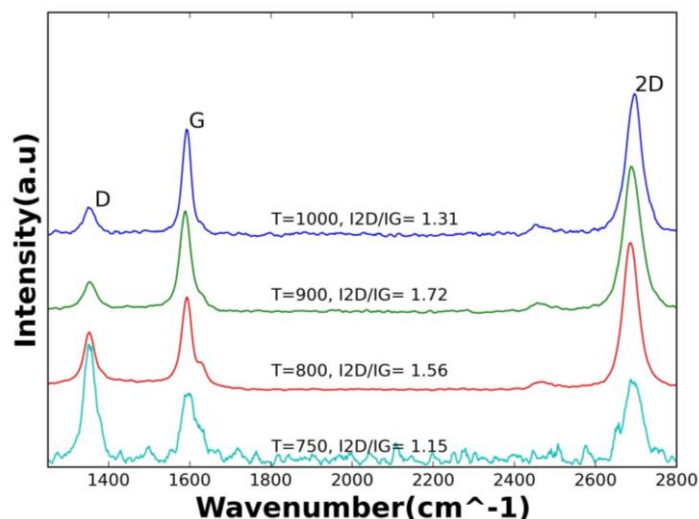
Graphene, serving as an ideal two-dimensional material platform, exhibits extraordinary electrical[1], optical[2], thermal[3] and mechanical[4, 5] properties. The growth of graphene at low temperature has been an outstanding goal for the community to avoid the drawbacks of the transfer process and directly grow in semiconductors that maybe affected by the high temperature growth [6].

Our study thus concentrates on the low temperature boundary limits in a known substrate like copper to understand the limits of the chemical vapor deposition (CVD) process and go to the lowest possible temperature. We started by growing the graphene at a descending temperature from 1000 °C to 700 °C on copper substrate. We then prove this process in a different substrate which is germanium at a temperature of 780 °C.

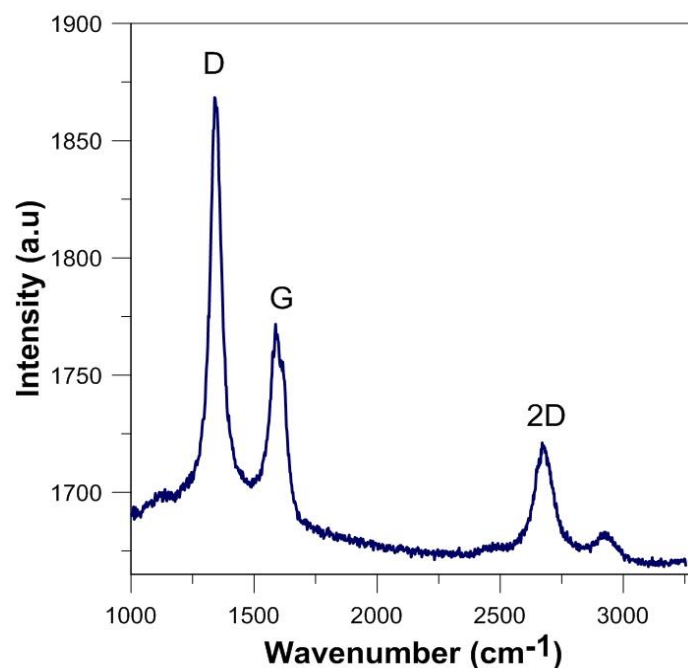
## References

- [1] X. Li, J. Feng, E. Wang, S. Meng, J. Klimeš, and A. Michaelides, *Physical Review B*, 85 (2012) 085425,
- [2] P. Avouris, *Nano Lett*, 11 (2010) 4285–4294
- [3] A. A. Balandin, *Nat Mater*, 10 (2011) 569-81
- [4] K. S. Kim, Y. Zhao, H. Jang, S. Y. Lee, J. M. Kim, K. S. Kim, et al., *Nature*, 457 (2009) 706-10
- [5] C. Lee, X. Wei, J. W. Kysar, and J. Hone, *Science*, 321 (2008) 385-8
- [6] Z. Li, Ping Wu, C. Wang, X. Fan, W. Zhang, C. Zeng, Z. Li, J. Yang, and J. Hou, *ACS Nano*, 4 (2011) 3385-3390

## Figures



**Figure 1:** Raman spectrum of graphene on copper at different temperatures



**Figure 2:** Raman spectrum of graphene on Germanium at 780 °C

