

## Production and characterization of graphene nanoplatelets by different industrial processes

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**Abstract :** Our presentation will review the potential and current areas of application for graphene, as well as the main production methods used to produce it. Graphene has entered the market in the composite space but many applications in the electronic sector are expected, notably for sensing (refs. 1-6) and memory (refs. 7,8). Energy storage (refs. 9,10) and conversion in fuel cells will also benefit from the very high stability, large surface area and especially the electric and thermal conductance displayed by this carbon allotrope. We will review the main graphene production methods, namely the Hummers' method, mechanical exfoliation, chemical vapour deposition and epitaxial growth as well as their difference in production capacity and resulting product characteristics. We will focus on mechanical exfoliation of graphite in the liquid phase and highlight significant and recent academic work performed with exfoliated graphene nano-platelets.

While the enthusiasm for graphene is strong, as shown by the large number of related publications and patent applications, there is a growing need for thorough characterisation of commercially available graphene as well as a clear framework for the interpretation of characterisation results. We will show how a combination of Raman spectroscopy, BET specific surface area measurement, thermogravimetric analysis and XPS measurement is necessary to obtain a good and statistically relevant product description. While microscopy is crucial for development, we feel that individual images can be misleading for customers given the very small sample size.

**NanoIntegris Technologies**, a Raymor subsidiary, is a world leading provider of **single-layer exfoliated graphene** and high mobility semiconductor inks. Our inks contain single to four layered graphene platelets or high-purity, sorted semiconducting single-walled carbon nanotubes. They are formulated for inkjet and aerosol printers and used in the development of the next generation of high-mobility transistors for sensing, logic and display driver applications. Founded in 1980, Raymor Industries is a high-end nanomaterials producer that supplies carbon nanotubes and other premium solutions and formulations primarily to the electronics market. Using a patented plasma technology, it synthesizes single-wall carbon nanotubes at industrial scale and with superior quality. Standing behind **over 450 academic publications** our materials were recognized with the **Best Technical Development Materials Award** at PE USA 2014.

### References :

1. Sando, S. et al., *MEMS*, 28, 324 – 327, 2015.
2. Benítez–Martínez, S. et al., *Microchemical Journal*, 121, 6-13, 2015.
3. Wang, D. et al., *Electrochemistry*, 83, 2, 84-90, 2015.
4. Radoi, A. et al., *Journal of Applied Electrochemistry*, 43, 985-994, 2013.
5. Zhang, B. et al., *Solid-State Sensors, Actuators and Microsystems*, 17, 143-146, 2013.
6. Zhang, B. and Cui, T., *ASME, IMECE* 15–21, 2013.
7. Nayfeh, A. et al., *ECS*, 2, 1879, 2014.
8. El-Atab, N., *Applied Physics Letters*, 105, 033102, 2014.
9. Kim, H-J., et al., *Physica E*, 61, 204-209, 2014.
10. Lee, SE. et al., *Nanoscale*, 19, 5, 8986-8991, 2013.
11. Boldeiu, A. et al., *Colloids and Surfaces A*, 461, 133-141, 2014.
12. Shim, J. et al., *ACS NanoLetters*, 14(3), 1388-1393, 2014.