Characterization of Few-layer Graphene (FLG) starting with Expanded Graphite

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Abstract

Graphene in currently moving swiftly from the research laboratory to the marketplace, driven by demand from markets where advanced materials are required. These include the aerospace, automotive, coatings, electronics, energy storage, coatings and paints, communications, sensor, solar, oil, and lubricant sectors. The exceptional electron and thermal transport, mechanical properties, barrier properties and high specific surface area of graphene and combinations thereof make it a potentially disruptive technology across a raft of industries. The European Union is funding a 10 year 1.35 billion euro coordination action on graphene. South Korea is spending $350 million on commercialization initiatives and the United Kingdom is investing £50million in a commercialization hub. Applications are coming onto the market for polymer composites and EMI shielding coatings. Graphene-based conducting inks are also finding their way into smart cards and radio-frequency identification tags. Many of the current and potential applications of carbon nanotubes may be taken by graphene as it displays enhanced properties but with greater ease of production and handling.

Graphene, in common with graphite, is a pure carbon modification whose structure consists of two-dimensional sheets of aromatic carbon. The individual atoms are hexagonally arranged and form a wrinkled surface. The first synthesis of graphene was made in the late 19th century [1], unfortunately without any precise characterization. However, based on its promising properties, the general interest in this carbon material increased rapidly. After fullerenes in 1985 [2] and carbon nanotubes in 1991 [3], graphene has become the "hot" carbon material in physical science. In 2004 graphene was unequivocally identified and studied by the physicists Andre Geim and Konstantin Novoselov [4]. In 2010, they both received the Nobel Prize in Physics for this work and are continuing to unveil new and exciting properties in graphene and other related two dimensional crystal materials.
For specific applications, the term graphene can be divided into the sub-groups Single Layer Graphene (1 layer), Bi-Layer Graphene (2 layers) and Few-Layer Graphene (3 to 9 layers). As a result of the following versatile properties, graphene is a material of choice in the future:-

- Chemical functionalization allowing improved compatibility in composite materials
- High elasticity and tensile strength
- Excellent barrier material for gas and liquids
- High electrical and thermal conductivity
- Microelectronics – graphene transistors

Possible future applications include:-

- Electrically conductive inks for printable electronic circuits
- LEC (Light-emitting electrochemical cell) – ultra-thin energy efficient lighting for use in displays, cameras etc.
- Stabilization of dispersions – for better processability
- Thin-film transistors – vertical field-effect transistors
- Impermeable membranes – efficient release films, raingear, gas filters, electro-mechanical switches

The results of the new method to make few-layer graphene (FLG) look very promising so far as the FLG material has 1 to 6 layers. Fig. 1: SEM of FLG flakes and Fig. 2: Raman of one of the FLG flakes:-

References

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[3] S. Iijima. Nature. **354**, (1991), 56-58.
[4] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva, A. A. Firsov. Science. **306**, (2004), 666-669.

Figures

SEM of FLG flakes and Fig. 2: Raman of one of the FLG flakes:-

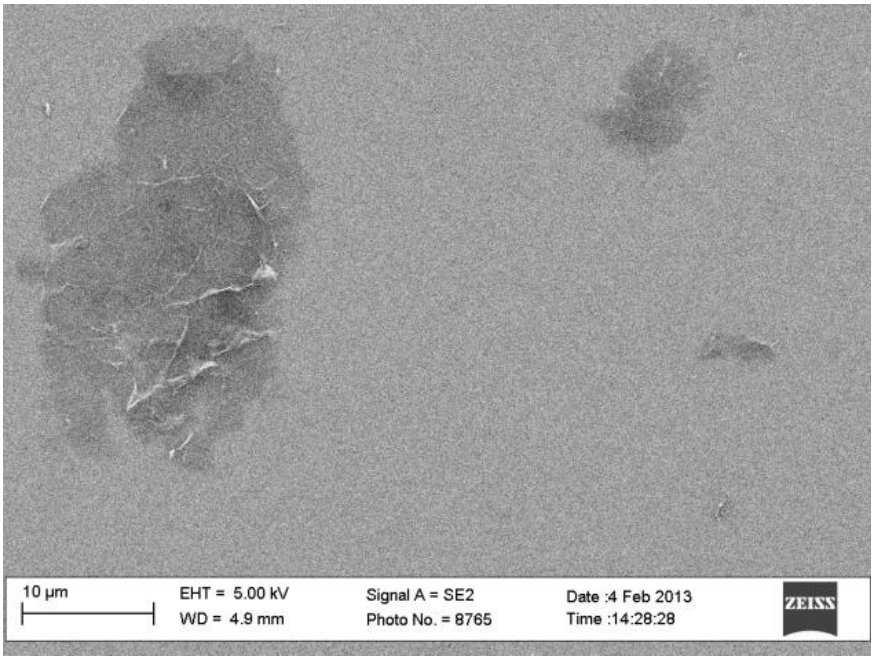

Figure 1. SEM detail of Few-Layer (FLG) flakes.

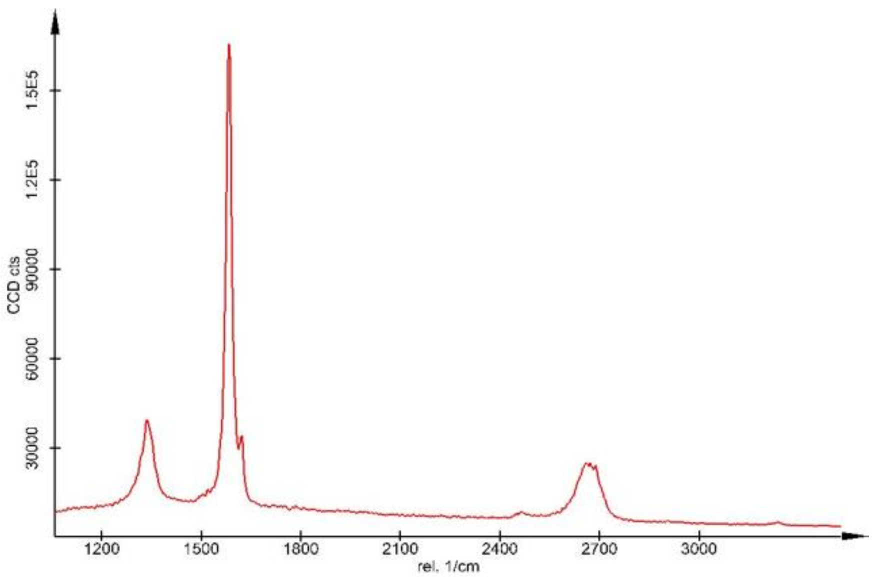

Figure 2. Raman of Few-Layer Graphene (FLG) flake.