

Bond Character of Carbon Cones and Discs

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Carbon cones have been named “the fifth form of carbon” and their unique topography make them promising for applications such as hydrogen storage, sensors and electrodes [1]. Cones and discs were produced by pyrolysis of heavy oil with a plasma arc in the Kvaerner Carbon Black and Hydrogen Process [2]. A subsequent study by Krishnan et al. reported that the observed cone apex angles of 112.9°, 84.6°, 60°, 38.9° and 19.2° corresponded to the incorporation of 1- 5 60° disclinations in a hexagonal graphitic sheet [3]. The discs may be regarded as cones with apex angles of 180°. A bright field micrograph of two cones supported by a holey carbon film is shown in figure 1.

It is of great interest to determine the electronic structure of these cones and discs for future applications. Electron Energy Loss Spectroscopy (EELS) in the TEM is an excellent technique for studying the electronic structure of each individual particle. In this work we present an investigation of the bond character of cones and discs by analysis of the carbon K ionization edge for a range of samples heat treated up to 2700°C. Sample orientation is known to affect the edge intensities due the anisotropy on graphitic structures. However, for a certain *magic* collection semi- angle, the normal and perpendicular scattering components are weighted so edge intensities are independent of sample orientation [4]. This collection condition was employed for accurate determination of edge intensities.

Bonding information was extracted by the method described by Zhili et al. [5]. Three Gaussians were fitted to the experimental ionization edges corresponding to a C=C π^* component (ca. 285 eV), C-C σ^* component (ca. 292 eV) and C=C σ^* component (ca. 300 eV). The sp^2 bonding character was then determined from the π^* component normalized to spectra from 100% sp^2 hybridized graphite (highly ordered pyrolytic graphite) [5]. Figure 2 shows a fitted carbon K ionization edge of a disc heat treated at 1600°C. A residual peak (ca. 287 eV) can be seen between the π^* and σ^* fits in figure 2. Zhili et al. suggested that this feature can be used as a measure of fullerene character [5]. We discuss this for the case of carbon cones and discs [6].

References

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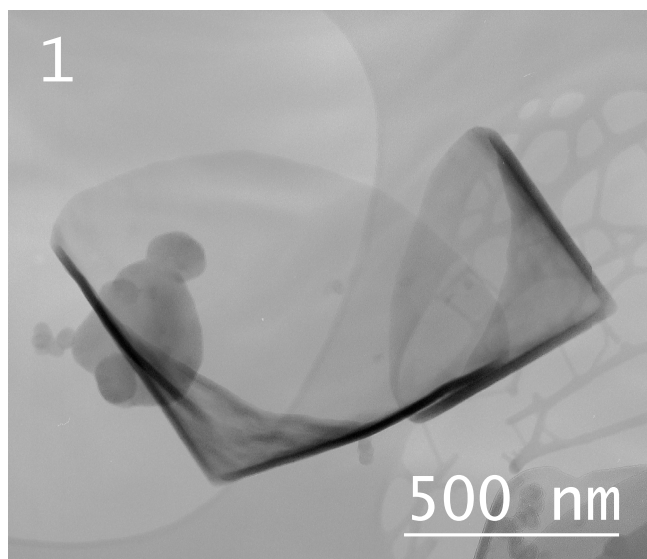


FIG. 1. A bright field micrograph of two non-heat treated cones. The particle attached to the largest cone is a cluster of carbon onion like structures.

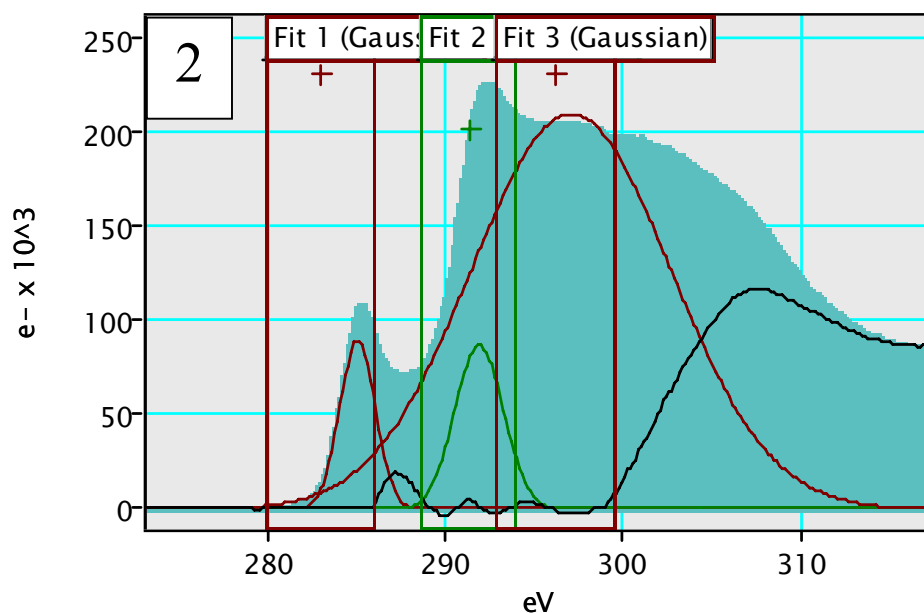


FIG. 2. A carbon K ionization edge of a disc heat treated at 1600°C fitted with three Gaussians. Note the residual peak at ca. 287 eV.