

## **Plasma production and functionalisation of Graphene and GNP's by plasma exfoliation**

**Ian Walters**

Haydale Ltd  
ECM2  
Port Talbot  
Wales  
SA132EZ  
ian@haydale.com

### Graphene

Graphene is known as the single-layer hexagonal form of carbon, corresponding to a single layer of the graphite structure but with properties exceeding graphite's because of the absence of neighboring layers. Graphene layers can be made to quite large sizes by careful mechanical "exfoliation" from graphite, reduction of exfoliated graphene oxide, or by epitaxial growth on substrates of other materials. However the known methods are laborious and expensive. Haydale Plasma processing introduces a valuable method of obtaining a material containing a significant proportion of useful graphene flakes or particles by a more convenient, environmentally friendly and economical method.

### Plasma

Haydale plasma treatment of particles of inorganic or mineral particulate material in which some or all of the particles comprise, consist of agglomerated, tangled or mutually cohering subsidiary or component particles or structures such as nanoparticles or atomic layers. Embodiments relate to carbon or carbon-containing materials, preferably in which the target component is graphene comprised in graphitic or stacked-graphene bodies. The Haydale plasma method is found to cause substantial and convenient disaggregation exfoliation and if required selective functionalisation that provides for enhanced dispersibility and covalent bonding within a desired matrix of the graphene flakes. The plasma treatment involves strategically positioning electrodes within a vacuum vessel. To control nano particle escape evacuation is provided via a suitable nano filter housing fabricated from materials that withstand plasma-processing conditions to avoid undesirable chemical or physical contamination of the nano product outputs.

During the plasma treatment, the application of vacuum is combined and balanced with a feed of gas for plasma formation, so that the treatment atmosphere can be controlled and contaminated or spent treatment gas removed during the process. Ports are incorporated into the treatment vessel for the injection of reagent or gas for chemical treatment.

### **Plasma Graphene Production**



Figures Stacked few Layer Graphene

