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Graphene – The New Material for Aviation

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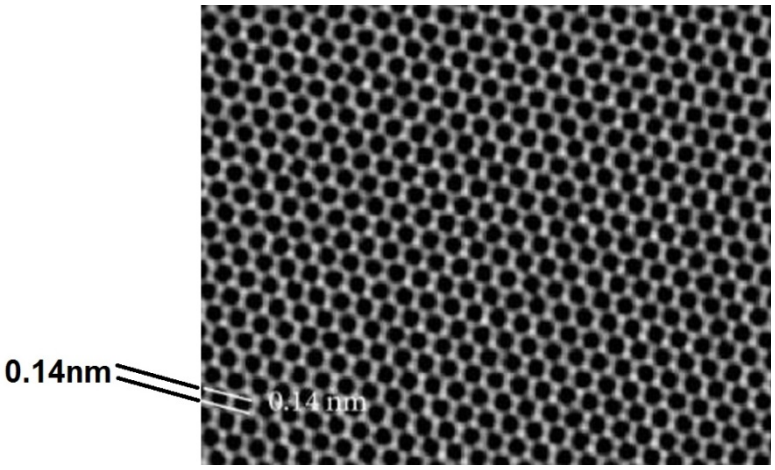
Graphene is a material of the future. Heralded frequently as a discovery, it is in fact a long-known variant of carbon that seemingly defied any synthesis until two researchers at the University of Manchester did something so simple barely a decade ago that when the presenter described their approach it seemed over simplified.

However, it was as simple as he said - Prof Andre Geim and Prof Kostya Novoselov "removed some flakes from a lump of bulk graphite with sticky tape. They noticed some flakes were thinner than others and by separating the graphite fragments repeatedly they managed to create flakes which were just one atom thick. They had isolated Graphene for the first time."[1]

Graphene is a single-molecule plate of carbon atoms that create a hexagonal pattern – only visible through an electron microscope.



The lattice-like structure of graphene is comparable to a natural honeycomb.

The scale quoted is 0.000001 x 0.14 metres.

This dimension will recur 7142.86 times per mm (or for old-timers 181,428 times per inch).

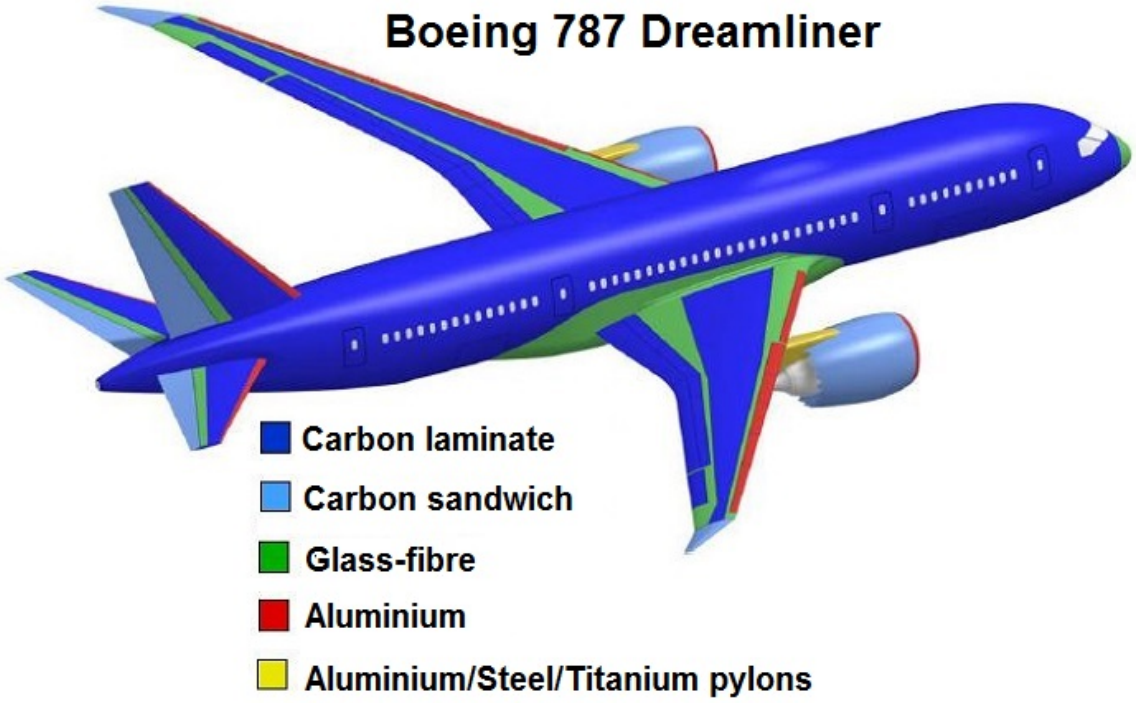
News of the ground-breaking synthesis of the first examples was published in the journal 'Science,' in 2004 and promoted the UK Government to subsequently fund the National Graphene Institute (NGI) at the University of Manchester. It was from that location that our speaker came to provide an opportunity to appreciate the full possibilities of this simple-looking and yet profoundly influential new material.

The presenter recognised that his audience comprised largely engineers rather than scientists, and his task of directing attention appropriately was a far from easy: the route taken had to transport knowledge over a new bridge between scientists and engineers and, not for the first time in history, has such a bridge been so visible to all, and yet so difficult to cross.

He started with a review of carbon-fibre structure influence on aviation, showing the Boeing 787 Dreamliner and Airbus A350 as prime examples of how carbon-fibre reinforced plastic (CFRP) has opened new avenues in civil aviation. No mention was made of military aircraft influences, but it has been fundamental too to recent generation vehicles of all sizes. He did not dwell on the evolution of

[1] National Graphene Institute (NGI), University of Manchester

Graphene in such applications, and the clear message was that such work was underway, but synthesis of the core product is still small-scale. Sources are now creating material in more substantial quantities with prices falling throughout recent years from astronomical to levels that are still expensive, but by now affordable enough for larger-scale research applications to be considered.



The theoretical possibility of a one-atom thick high-strength structure was acknowledged, but not investigated or condoned. Interest focussed on multi-layer, but still astonishingly thin, structures, whose advantages over carbon-fibre were not just mass reduction – a property particularly valued in aviation – but also their comparable performance in terms of whether the new material is able to outperform CFRP in terms of resistance to cracking, avoidance of fibre waviness in manufacture, and in-service issues such as water ingress and delamination.

He concentrated on engineering-related properties, citing thermal, electrical and mechanical research outcomes, and centred on his involvement in manufacturing research into the curing processes through 'pre-dispersion' and 'dispersion' stages.

When graphene nanoparticles (GNP) are initially dispersed in an epoxy resin they do not necessarily agglomerate as desired, and may create only weak bonds between the GNP and epoxy molecules. Research is looking at ways of encouraging the creation of stronger bonds to form a strong three-dimensional network through the pre-dispersion stage, and simultaneously addressing the preferred relationships between the matrix configuration and the desired mechanical, thermal and electrical properties.

Dispersion is the next step towards synthesising the qualities of the conglomerate of GNP into the epoxy – a process that might be interpreted as a 'cooking recipe'. In this way desired thermal and electrical properties seem likely to be attainable by controlling the formation in the matrix through different techniques before or during the curing process.

Potential properties that were acknowledged referred to fracture toughness and de-icing property in aircraft. These ran away faster than my note-making skills could muster, but the issue of whether one could self-heal a fracture in-situ was akin to being given hope of something exceptional. De-icing by having a skin that will deliver appropriate electrical load (low current desired) to generate heat is being investigated too. There was also some confidence that 'shape morphing' might be possible. Even if the extent and control of flexibility doesn't live up to science-fiction dreams initially, the prospect of such evolution over time is certainly something to regard as welcoming in the future.

Some of them will be steps into territory previously out of sight, but there were hints too of new perspectives on many issues that fertile minds will no doubt explore in the future. As such it was a profound reminder of the challenges facing modern engineers when they come to encompass new avenues of exploration.

In the Q and A session a question on Far East interest in Graphene related patents enticed the comment that Samsung (South Korea) is one company looking at innovation in the field, and one wonders what such developers in the commercial product sector will create that will influence the design of the elements of aircraft, with flight-deck display and control philosophies without the boundaries that exist today, perhaps being amongst developments influenced by this technology that will come to the fore (if the flight deck is not abolished).

Our speaker confirmed that there is a second specialist Graphene Centre under construction and adjacent to existing facilities at the University of Manchester's 'Graphene City'. It will be the 'Graphene Engineering Innovation Centre,' which is due to open in 2018, and has been backed by £60 million of government and industrial funding.

The NGI team already seem to have made admirable inroads into the scope that the new organisation will address in due course. It was without doubt a presentation that our 130 or so attendees found both interesting and informative, and it is those attributes that have been difficult to draw from a fast-moving session. While ever we have people with such passion to create, and not just explore, future possibilities, there will be a strong future.

Lecture notes by Mike Hirst