MATERIAL WITNESS

Green-sky thinking

Rightly or wrongly, aviation has been cast as one of the prime villains of global warming. To some, it seems unfair to lay so much blame on an industry that contributes less than two percent of global greenhouse gas emissions. To others, the extravagant fuel needs of airlines highlights all that is wrong with today's profligate disregard for the environmental costs of an industrialized lifestyle. This polarity has come to the fore in furious arguments over the planned expansion of British airports.

Will increased air travel mean that civil aviation accounts for an ever-increasing proportion of carbon emissions? That depends partly on whether it can be made more fuel-efficient, in particular by using advanced materials to reduce airplane weight. Lightweight structural materials for aerospace are an often neglected aspect of the roles that materials science can play in the future of energy.

Admittedly, the drive towards fuel efficiency in aviation can be attributed as much to soaring oil prices as to concerns about global warming — but there's little question that the industry would appreciate a greener image. Composites based on carbon and glass fibres are already replacing aluminium alloys in aircraft, and planes containing up to 50 percent by weight of such materials are envisaged for the future. Some claim this will help to halve fuel use by 2020.

Much of the discussion now crystallizes around the double-decker 'superjumbo' A380 made by the European company Airbus, which had its first commercial flight last year. Airbus claims that the A380's lightweight structure means it burns 17 percent less fuel per seat than other large aircraft, and produces only half the carbon dioxide emissions per passenger per kilometre stipulated by the European Union for new cars.

Composites make up a quarter of the A380's weight. The upper fuselage uses a new aluminium–glass fibre laminate called GLARE, developed and produced in the Netherlands, which has improved corrosion- and impact-resistance. The aircraft body also contains a honeycomb composite of high-strength Kevlar.

The high temperatures experienced by engine parts make it hard to eliminate a reliance on metal alloys, but even here there are alternatives. In particular, most jet engines, including those of the A380, now contain parts made from DuPont's Vespel, an aromatic polyimide with high thermal stability.

It's worth remembering that the intrinsic materials are only part of the equation; there's also the matter of how easy they are to assemble, and how reliable they are. The use of thermoplastic rather than thermosetting polymer resins makes moulding easy, and means that parts can be joined by welding rather than needing labour-intensive adhesive bonding and riveting. The A380 makes extensive use of thermoplastic composites, for example in the leading edges of the wings.

There are obvious implications of these new technologies for other forms of transportation, from domestic cars to space rockets. That they are typically costly is a hurdle, but with rising fuel prices and the prospect of carbon taxes the economic balance sheet may soon look very different.

Philip Ball

FULLERIDES

Competition fix

The complex electronic properties of alkali-doped fullerides derive from the interplay between competing interactions. Fine control of the doping levels and thickness of fulleride films makes it possible to tune relevant parameters.

Olle Gunnarsson

is at the Max-Planck Institut für Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart, Germany.

e-mail: O.Gunnarsson@fkf.mpg.de

Alkali-doped fullerides — that is, solids of fullerene molecules (C_{60}) intercalated by alkali atoms — have attracted considerable interest, both because of the observation of superconductivity at rather high transition temperatures (30–40 K)[1] and because of unusual properties exhibited by this class of materials as a consequence of the competing electronic interactions. It is known that electrons interact strongly with lattice vibrations, in particular with Jahn–Teller phonons, which are associated with geometrical distortions of the C_{60} molecules[2]. This interaction is believed to drive superconductivity[3–5]. On the other hand, the interplay between Coulomb repulsion, electron–phonon interaction and hopping can drive some fullerides from a metallic to an insulating state. Understanding the role of each interaction is quite difficult because it is not easy experimentally to isolate one parameter from the other. Writing on page 194 of this issue, Wang and co-workers[6] provide

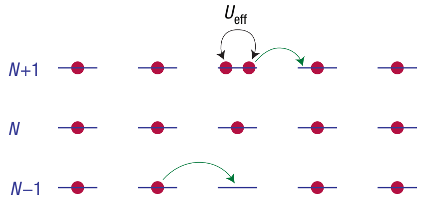

Figure 1 Typical electron occupancies for the initial state (panel N) and final states with an added ($N+1$) or subtracted ($N-1$) electron for the case of one electron per molecule (in K_1C_{60}) and a large U_{eff}. The green arrows indicate important hopping possibilities for the latter two states.