Nanotechnology in aviation There are few industries where the applications of nanotechnology are so clearly beneficial as in the aerospace industry. The primary development goals match almost exactly with the advantages offered by using various nanomaterials in the place of traditional metals like steel. The aerospace industry is one of the most important heavy industries in the world. Countless companies rely on the ability to ship products and people around the world with the speed that can only be achieved by air. Along with this huge economic value, however, comes huge consumption, and one of the largest carbon footprints on the planet relative to the size of the market. For this reason, the major drivers in current aerospace industry are towards lighter construction materials and more efficient engines – the overall goal being to reduce fuel consumption and carbon emissions associated with air travel and air freight. The significant interest in nanotechnology for the aerospace industry is justified by the potential of nanomaterials to help the industry achieve this goal. Nanotechnology is recognized as a very strong innovation driver and is therefore seen as a strategic technology for the world’s future economy. Nanomaterials with their exceptional multifunctional properties may transform the functioning of aviation industry dramatically. The success of the aviation industry depends on various factors ranging from reduction of weight, availability of materials with multifunctional properties, eco–friendly fuels, less fuel consumption, faster and highly responsive communication systems, less or no repairs, extended life, reduced time limit of development cycle from concept to implementation and many more. The following will review some of the nanomaterials which are already being applied in aerospace manufacturing, and the benefits they can provide. Nanostructured metals Metals with some nanoscale structure are already widely used in aircraft manufacturing. It is now well known that nanostructured metals – exhibit considerably improved properties compared to their counterparts with microscale or larger grain structure. This is particularly noticeable for properties which are crucial for materials used in aircraft – primarily yield strength, tensile strength and corrosion resistance, coupled with low density which helps keep the total weight of the aircraft down. Comparison of microstructures of titanium before and after nanostructuring Initial Titanium After Nanostructuring Polymer nanocomposites Polymer–layered nanocomposites Various nanomaterials have been used as filler materials to enhance the properties of structural and non–structural polymers used in aircraft construction. The most commonly used nanomaterials include nanoclays, carbon nanotubes, nanofibres, and graphene. Carbon nanotubes in particular have been shown to give excellent advantages when used as fillers in various polymers, due to their exceptional stiffness, toughness, and unique electrical properties. Nanocomposites typically have superb weight–to–strength ratios, and enhanced resilience to vibration and fire, making them ideal for use in the aviation industry. The properties of the nanofillers, like the conductivity of nanotubes, for example, can create interesting opportunities for multifunctional materials. The properties of polymers enhanced by nanomaterial fillers are so well–tuned to the requirements of aircraft manufacturers, that they are actually being used to replace some of the metals used in the airframes. This obviously brings along huge weight savings, and often cost savings as well. Tribological and Anti–Corrosion Coatings New nano–coatings have an anti–adhesive, anti–corrosive and antimicrobial effect Another major trend in the materials used in aircraft is towards nanocoatings to enhance the durability of metals. In particular, magnesium alloys, which are far lighter than steel or aluminium, are prone to corrosion, due to the high
chemical reactivity of magnesium. Coatings can help prevent corrosion, but the types normally used contain chromium complexes which are a highly toxic pollutant. Materials used for these novel anti-corrosion nanocoatings include silicon and boron oxides, and cobalt-phosphorous nanocrystals. Nanocoatings are also now being used on turbine blades and other mechanical components which have to withstand high temperatures and friction wear. Tribological coatings can drastically lower the friction coefficient and improve resistance to wear – this greatly improves the efficiency of the engines. Many nanostructured and nanoscale coating materials have been suggested as possible friction modifying agents, such as carbides, nitrides, metals, and various ceramics. This is just a brief overview of some of the nanomaterials being used in aerospace. The main roadblock, as with many industries looking to adopt nanotechnology, is caused by uncertainty over the environmental and health and safety implications of these materials. While nanomaterials can often be less toxic than the current materials used, the effects of long-term exposure to these novel materials are still uncertain. The potential of nanotechnology in the aerospace industry cannot be denied, however. Nanotechnology is also helping engineers to create space vehicles with the necessary properties to endure the harsh conditions of space.