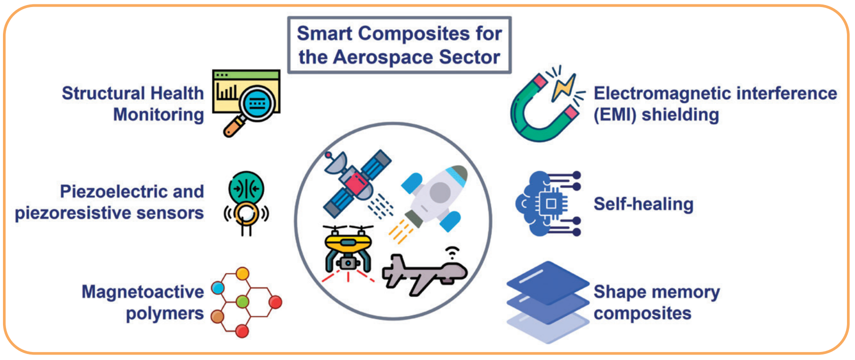
Nanomaterials in aerospace engineering

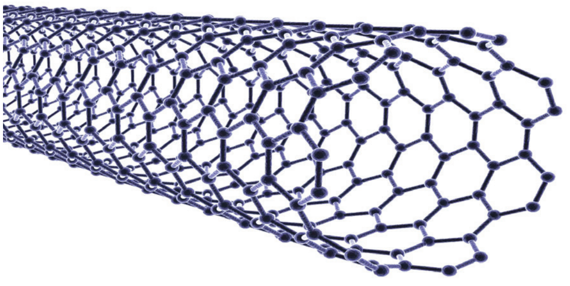


Nanomaterials are materials engineered on a very small scale, typically between 1 and 100 nanometres. On this scale, materials often show unique mechanical, thermal, and electrical properties that are different from their bulk form. In aerospace engineering, these materials are transforming the design and performance of aircraft and spacecraft. Agencies such as NASA and companies like Airbus and Boeing invest in nanotechnology research to create lighter, stronger, and more efficient vehicles. Since every kilogram saved in an aircraft or rocket reduces fuel consumption and cost, nanomaterials improve sustainability and performance in the aerospace sector.

Types and key applications

Several types of nanomaterials are currently used or tested in aerospace engineering:

- **Carbon nanotubes (CNTs)**, extremely strong and lightweight, reinforce composite materials used in fuselages and wings;
- **Graphene-based materials** improve electrical conductivity and mechanical strength in structural components;



- **Nanocoatings** protect surfaces from corrosion, extreme temperatures, and radiation exposure;
- **Nano-enhanced polymers** increase resistance to fatigue and mechanical stress;
- **Nanoparticles in fuels** enhance combustion efficiency and reduce harmful emissions.

Advantages for performance and safety

The main advantage of nanomaterials in aerospace is their exceptional strength-to-weight ratio. By incorporating nanoscale reinforcements into composite materials, engineers can reduce structural weight without reducing safety. Improved thermal resistance is another benefit, especially for spacecraft exposed to high temperatures during atmospheric re-entry. Additionally, smart nanomaterials can be integrated with sensors to monitor structural health in real time, detecting cracks or stress before they become critical. This predictive maintenance approach increases reliability and reduces operational risks.

Challenges and future perspectives

Despite their advantages, nanomaterials have challenges such as high production costs, large-scale manufacturing difficulties, and concerns about environmental and health impacts. Researchers are working to improve fabrication techniques and ensure safe handling procedures. In the future, nanotechnology may enable self-healing materials that automatically repair microscopic damage, increasing aircraft lifespan. As research advances, nanomaterials are expected to play an even greater role in aerospace innovation, supporting safer flights, lower emissions, and more ambitious space exploration missions.

bulk: *massa*
fuselage: *fusoliera*
rocket: *razzo*
self-healing: *autoriparante*

1 Answer the questions.

1. What are nanomaterials?
2. Why have nanomaterials got unique properties?
3. Why are nanomaterials important in aerospace engineering?
4. Why does reducing weight matter in aircraft and rockets?
5. How are carbon nanotubes used in aerospace?
6. What is the function of nanocoatings?
7. How do nanomaterials improve safety?
8. What are some challenges of using nanomaterials?

2 Match the terms with the definitions.

1. Nanomaterials
2. Carbon nanotubes
3. Graphene-based materials
4. Nanocoatings
5. Nano-enhanced polymers
6. Nanoparticles in fuels
7. Strength-to-weight ratio
8. Thermal resistance
9. Predictive maintenance
10. Self-healing materials

- ☐ **a.** The relationship between how strong a material is and how heavy it is.
- ☐ **b.** Advanced materials that can automatically repair small cracks or damage.
- ☐ **c.** Thin protective layers that prevent corrosion and resist radiation or heat.
- ☐ **d.** Materials engineered at a scale between 1 and 100 nanometres.
- **e.** Tiny particles added to fuel to improve combustion and reduce emissions.
- ☐ **f.** The ability of a material to withstand very high temperatures.
- ☐ **g.** A system that detects structural problems before they become serious.
- ☐ **h.** Extremely strong cylindrical nanostructures used to reinforce composites.
- ☐
- ☐ **i.** Polymers improved with nanoscale additives to resist fatigue and stress.
- ☐ **j.** Materials that improve electrical conductivity and mechanical strength.

3 Choose one type of nanomaterial and create a short report or presentation including the following information.

- Its chemical or structural properties
- How it is applied in aircraft or spacecraft
- Advantages it provides compared to traditional materials
- Potential challenges in using it (cost, production, safety, environmental impact)

EXTREME TEMPERATURES IN SPACE

Spacecraft can experience extreme temperature variations depending on their exposure to the sun. In shadow (or deep space) temperatures can drop to around –150°C to –270°C, whereas surfaces exposed to the sun can reach +120°C to +150°C in Earth orbit. Nearer to the sun (for example, missions like Parker Solar Probe) spacecraft can experience external temperatures of over 1,000°C on their heat shields.