NASA Facts

National Aeronautics
and Space Administration

Langley Research Center
Hampton, Virginia 23681
Office of Public Affairs

FS-1996-08-07-LaRC

Futuristic Materials – Part of Our Present

The next time you fly in an airplane, notice the wing. In the future, instead of aluminum, you may be looking at one of this century's advances in materials, called a graphite composite, developed in part by researchers at NASA's Langley Research Center.

The next time you open a singing greeting card, you are using the same piezoelectric technology that NASA Langley uses in the moving parts of its satellites. And there are many more ways you use these new materials every day.

In the Research and Technology and Internal Operations Groups at NASA Langley, scientists focus on the performance, durability, economy and environmental compatibility of civil and military aircraft and spacecraft. These include launch systems, space science instruments, spacecraft, re-entry and high-speed flight vehicles, as well as commercial and general aviation airplanes. NASA Langley's research not only centers on design, but on the development of durable materials which make the design and

Important Considerations

The goal of all research in materials is to improve performance, including damage, stress and heat tolerance, while reducing processing and fabrication costs. There is no ideal material to meet every need. In fact, a desired characteristic in one application may be a disadvantage in another. Researchers consider many characteristics and weigh them either as a pro or a con for a given application.

Light weight. It takes ten pounds of resources to get one pound into space and back. Therefore, the lighter the material, the less costly it is to get a structure into space.

Dimensional stability. A low-Earth-orbit spacecraft, such as the International Space Station, circles Earth every 90 minutes. During each orbit, there are periods of extreme hot and cold which can cause most materials, as the spacecraft moves in and out of the Earth's shadow, to expand and contract, changing their size and shape as the temperature changes. A "dimensionally stable" material retains its size and shape with changes in temperature – this is a critical factor in many applications.

Lifetime prediction. Some missions run for years, some last only a few weeks. The lifetime of a material can determine the length of the mission and if not predicted correctly can lead to premature failure.

Environmental stability and durability. Components must be durable in the harsh space environment which includes radiation, atomic oxygen and vacuum.

Strength/stiffness. How much load a material can take and how flexible it is are two different considerations determined by each application.

Manufacturability. A material that is hazardous to the people who are manufacturing it or to the environment can be more expensive to make because of the special requirements to handle and dispose of it.

Cost effectiveness. The cost of a material, including production and testing, is a major consideration and can be the determining factor in whether or not it is used.

performance possible. While these materials are developed to meet aerospace needs, they are meeting consumer needs, too, in a variety of technological "spin-offs."

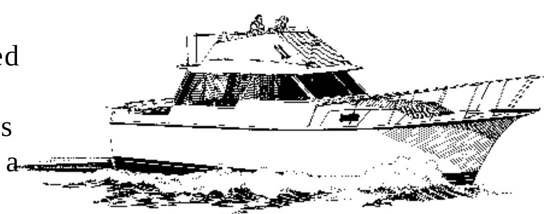
MAJOR MATERIAL GROUPS

Composites

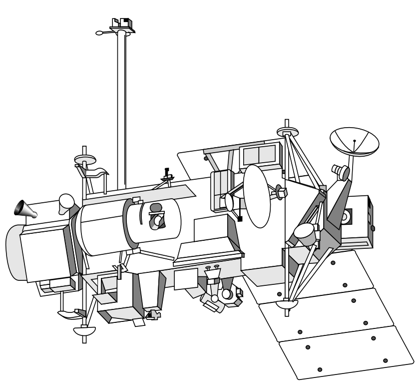
A composite is a combination of two or more materials: a reinforcing material for strength and stiffness, and a glue or binding material, such as a resin, to surround and hold the reinforcement in place.

reinforcer + binder = composite
(example, graphite fiber) (example, polymer resin)

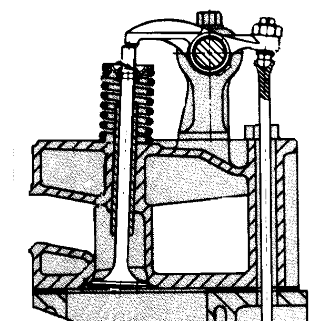
The concept is hardly new. The ancient Egyptians used a very basic composite material in the construction of their houses — mud and straw. They combined two materials to make a third stronger one. A more sophisticated example would be the graphite composites used in fishing poles, golf clubs, boat hulls and even automobile bodies. NASA Langley researchers are developing new composites to meet the stringent demands of space and to advance aerospace vehicle capabilities.



An example is the ***micro-composites*** group of materials. Micro-composites may be used in the future in the aerospace industry for screws, rings and mirrors, to name a few components. Micro-composites combine a carbon, metal or ceramic base (reinforcer) with a polymer (glue) to produce a material which can withstand extreme temperatures — from almost 400°F to below freezing. Depending on further temperature and stress requirements, the material can be sintered (baked) at extremely high temperatures and then molded into the appropriate shape.



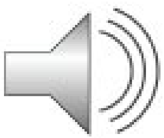
Micro-composite carbons, metals and ceramics have many advantages. They can be produced very easily and cost efficiently. They can be tailored to meet specific requirements in strength, and electrical and thermal conductivity. Micro-composites are environmentally resistant, and can be designed not to absorb water which later is outgassed, or given off, causing the structure to change weight or shape.



NASA Langley's biggest contribution to micro-composite research has been new processing techniques which are allowing for efficiency and cost savings. Industry spin-offs include shaft seals, valves and bearings in rotating equipment like automobiles.

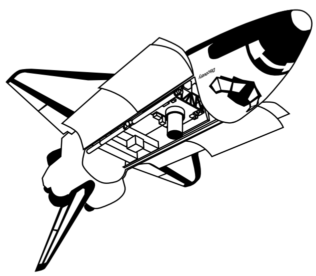
Another composite material is called ***piezoelectric*** (pi·e´zo·e·lec´tric) A ceramic, this material is considered "smart" because it responds to electrical impulses by moving or changing its shape. Its ability to move makes the material an actuator, causing mechanical movement in other components. It also serves as a sensor, indicating when heat, light, motion or pressure has changed. In the past, piezoelectric materials have been able to move only small amounts. NASA Langley has developed the technology which now enables as much as a half inch of movement.

Anyone who has a stereo system at home is using piezoelectric technology. Positioned in the tweeter part of the stereo speaker, this



material acts as a sound modulator, vibrating according to programmed frequencies. Piezoelectric materials are also used to reduce noise in airplanes by canceling out certain noise frequencies as they vibrate to a different frequency.

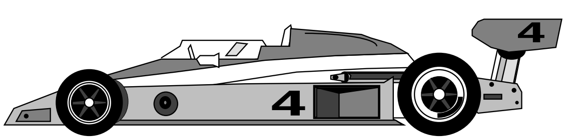
In the aerospace industry, piezoelectric components serve where there are moving parts in satellites, in optical positioning and for onboard corrections. This material is replacing motors which are heavy and require large housing. Its advantages are that it is lightweight, requires little power and is highly reliable.



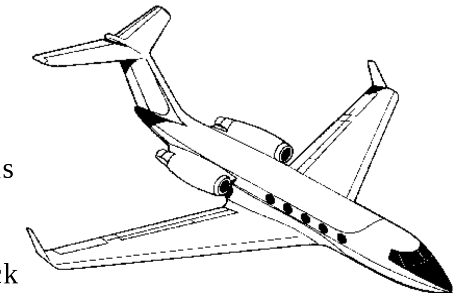
Carbon-Carbon materials make up another group of composites. These, too, are ceramics made in high temperatures where carbon particles are bonded in a carbon matrix. They can withstand extreme heat, like in the nozzle cone of a rocket and in a space capsule's heat shield. Perhaps the best known use of carbon-carbon composites is the black nose cone on the space shuttle. Carbon-carbon materials are used to protect the nose and leading edges of the wings from the searing heat of re-entry into Earth's atmosphere.

> Currently, carbon-carbon materials are used in a component separate from the main structure of the space shuttle. NASA Langley scientists are working to integrate it into the structure, thereby saving weight. This achievement will pave the way for the development of advanced hypersonic vehicles which require a surface material to withstand 3000°F.

We also find carbon-carbon materials in the brakes and clutches of Formula I and Indy race cars where they have replaced asbestos linings.



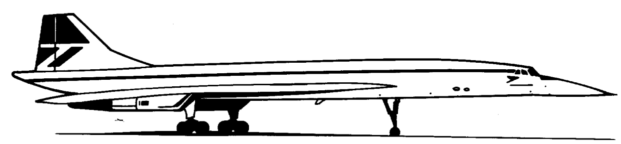
Metals make up another materials group, specifically aluminum lithium and improved titanium alloys.



An advantage of metal over other materials is its ductility (bendability). It doesn't crack easily and can be repaired if dented. It can tolerate a great deal of strain before it fails. The new metals are an improvement over other aluminum alloys. In addition to being stronger and stiffer, they are lighter weight which means vehicles can have smaller engines, carry less fuel and fly longer.

NASA Langley's goal is to make them more cost effective. They are currently working with Russian scientists to integrate their more affordable metals technology into United States' technology for more widespread use on commercial airplanes.

Although expensive, the improved titanium alloy is being developed for application on a supersonic transport. This material can tolerate extreme heat to accommodate the aerodynamic thermal requirements of Mach 2.4. Temperatures at that speed reach 300 – 350°F.



NASA Langley researchers are providing the technological development to allow U.S. industry to determine if this project will be economically feasible by the turn of the century.

New metals are now used mainly in rocket tanks, such as the external tank on the space shuttle. The material has the potential to save 4500 to 5000 pounds, allowing the shuttle to increase its payload.

Commercial applications include components in the automobile industry.

Contribution to Industry

NASA Langley’s research in materials is giving the United States a technological advantage in many areas, both in aerospace and general industry. Because of its work in metals, it is opening the way to a market for a new generation of supersonic airliners. Its development of advanced aluminum alloys and composites will help reduce airframe weight. NASA Langley has also developed a polymer binder which is also a basic ingredient in many cosmetic products. Until now, it has only been available overseas.

NASA has also taken a bold step in the development of twenty-first century technologies with its New Millennium Program. This program will focus on increasing spacecraft capabilities, reducing costs and increasing flight rate. To do this it will use small launch vehicles powered by micro-spacecraft and micro-instruments. The successful development of these vehicles depends on new materials available.

From a nozzle cone on a rocket to the brakes on a race car, NASA Langley's development of new materials is influencing not only the way we explore space and travel but the way we live on Earth as well. While these materials were created as part of aerospace research, many have “spin-offs” which bring the new technology to our everyday life.

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