

optimizing the performances of PBO fibers so as to minimize their contribution to vulnerability of the pressure vessel to stress rupture had yet to be performed.

*This work was done by Thomas K. DeLay of Marshall Space Flight Center and James E. Patterson and Michael A. Olson of HyPer-Comp Engineering, Inc.
This invention is owned by NASA, and a*

patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31838-1.

Making High-Tensile-Strength Amalgam Components

Instead of spheroids or flakes, wires are used as the solid constituents.

Marshall Space Flight Center, Alabama

Structural components made of amalgams can be made to have tensile strengths much greater than previously known to be possible. Amalgams, perhaps best known for their use in dental fillings, have several useful attributes, including room-temperature fabrication, corrosion resistance, dimensional stability, and high compressive strength. However, the range of applications of amalgams has been limited by their very small tensile strengths. Now, it has been discovered that the tensile strength of an amalgam depends critically on the sizes and shapes of the particles from which it is made and, consequently, the tensile strength can be greatly increased through suitable choice of the particles.

The term “amalgam” generally denotes an alloy of mercury with one or more other metals (e.g., copper or a copper alloy in the case of dental fillings). Amalgams can also be based on gallium, or gallium alloys, which melt near room temperature. An amalgam is formed by a peritectic reaction in a process called “trituration,” in which the solid metal (e.g., copper) in powder form is ground together with the liquid

metal (e.g., gallium). The grinding serves to break the oxide skin on the solid metal particles, enabling wetting of the clean metal surfaces by the liquid metal. The liquid metal reacts with the solid metal to form a new solid that is a composite of the starting solid metal (e.g., Cu) and an intermetallic compound (e.g., CuGa).

Heretofore, the powder particles used to make amalgams have been, variously, in the form of micron-sized spheroids or flakes. The tensile reinforcement contributed by the spheroids and flakes is minimal because fracture paths simply go around these particles. However, if spheroids or flakes are replaced by strands having greater lengths, then tensile reinforcement can be increased significantly. The feasibility of this concept was shown in an experiment in which electrical copper wires, serving as demonstration substitutes for copper powder particles, were triturated with gallium by use of a mortar and pestle and the resulting amalgam was compressed into a mold. The tensile strength of the amalgam specimen was then measured and found to be greater than 10^4 psi (greater than about 69 MPa).

Proceeding forward from this demonstration of feasibility, much remains to be done to optimize the properties of amalgams for various applications through suitable choice of starting constituents and modification of the trituration and molding processes. The choice of wire size and composition is expected to be especially important. Perusal of phase diagrams of metal mixtures could give insight that would enable choices of solid and liquid metal constituents. For example, phase diagrams have revealed that gallium should form amalgams with iron and nickel (as already demonstrated), as well as zirconium, and titanium. Finally, whereas heretofore, only binary alloys have been considered for amalgams, ternary additions to liquid or solid components should be considered as means to impart desired properties to amalgams.

This work was done by Richard Grugel of Marshall Space Flight Center.

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Bonding by Hydroxide-Catalyzed Hydration and Dehydration

Room-temperature process can be varied to suit optical and non-optical applications.

Marshall Space Flight Center, Alabama

A simple, inexpensive method for bonding solid objects exploits hydroxide-catalyzed hydration and dehydration to form silicatelike networks in thin surface and interfacial layers between the objects. (Silicatelike networks are chemical-bond networks similar to, but looser than, those of bulk silica). The method can be practiced at room temperature or over a wide range of temperatures.

The method was developed especially to enable the formation of precise, reli-

able bonds between precise optical components. The bonds thus formed exhibit the precision and transparency of bonds formed by the conventional optical-contact method and the strength and reliability of high-temperature frit bonds. The method also lends itself to numerous non-optical applications in which there are requirements for precise bonds and/or requirements for bonds, whether precise or imprecise, that can reliably withstand severe environmental condi-

tions. Categories of such non-optical applications include forming composite materials, coating substrates, forming laminate structures, and preparing objects of defined geometry and composition.

The method is applicable to materials that either (1) can form silicatelike networks in the sense that they have silicatelike molecular structures that are extensible into silicatelike networks or (2) can be chemically linked to silicatelike networks by means of hydroxide-