



Materials & Coatings

Ambient Dried Aerogels

NASA's Jet Propulsion Laboratory, Pasadena, California

A method has been developed for creating aerogel using normal pressure and ambient temperatures. All spacecraft, satellites, and landers require the use of thermal insulation due to the extreme environments encountered in space and on extraterrestrial bodies. Ambient dried aerogels introduce the possibility of using aerogel as thermal insulation in a wide variety of instances where supercritically dried aerogels cannot be used. More specifically, thermoelectric devices can use ambient dried aerogel, where the advantages are in situ production using the cast-in ability of an aerogel.

Previously, aerogels required supercritical conditions (high temperature and high pressure) to be dried. Ambi-

ent dried aerogels can be dried at room temperature and pressure. This allows many materials, such as plastics and certain metal alloys that cannot survive supercritical conditions, to be directly immersed in liquid aerogel precursor and then encapsulated in the final, dried aerogel. Additionally, the metalized Mylar films that could not survive the previous methods of making aerogels can survive the ambient drying technique, thus making multilayer insulation (MLI) materials possible. This results in lighter insulation material as well.

Because this innovation does not require high-temperature or high-pressure drying, ambient dried aerogels are much less expensive to produce. The

equipment needed to conduct supercritical drying costs many tens of thousands of dollars, and has associated running expenses for power, pressurized gasses, and maintenance. The ambient drying process also expands the size of the pieces of aerogel that can be made because a high-temperature, high-pressure system typically has internal dimensions of up to 30 cm in diameter and 60 cm in height. In the case of this innovation, the only limitation on the size of the aerogels produced would be in the ability of the solvent in the wet gel to escape from the gel network.

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Applications for Gradient Metal Alloys Fabricated Using Additive Manufacturing

A new roadmap for gradient metals that could be used in cars, optics, aircraft, and sporting goods.

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Recently, additive manufacturing (AM) techniques have been developed that may shift the paradigm of traditional metal production by allowing complex net-shaped hardware to be built up layer-by-layer, rather than being machined from a billet. The AM process is ubiquitous with polymers due to their low melting temperatures, fast curing, and controllable viscosity, and 3D printers are widely available as commercial or consumer products. 3D printing with metals is inherently more complicated than with polymers due to their higher melting temperatures and reactivity with air, particularly when heated or molten. The process generally requires a high-power laser or other focused heat source, like an electron beam, for precise melting and deposition. Several promising metal AM techniques have been developed, including laser deposition (also called laser engineered net shaping or LENS® and laser

deposition technology (LDT)), direct metal laser sintering (DMLS), and electron beam free-form (EBF). These machines typically use powders or wire feedstock that are melted and deposited using a laser or electron beam. Complex net-shape parts have been widely demonstrated using these (and other) AM techniques and the process appears to be a promising alternative to machining in some cases.

Rather than simply competing with traditional machining for cost and time savings, the true advantage of AM involves the fabrication of hardware that cannot be produced using other techniques. This could include parts with "blind" features (like foams or trusses), parts that are difficult to machine conventionally, or parts made from materials that do not exist in bulk forms. In this work, the inventors identify that several AM techniques can be used to develop metal parts that change composi-

tion from one location in the part to another, allowing for complete control over the mechanical or physical properties. This changes the paradigm for conventional metal fabrication, which relies on an assortment of "post-processing" methods to locally alter properties (such as coating, heat treating, work hardening, shot peening, etching, anodizing, among others). Building the final part in an additive process allows for the development of an entirely new class of metals, so-called "functionally graded metals" or "gradient alloys." By carefully blending feedstock materials with different properties in an AM process, hardware can be developed with properties that cannot be obtained using other techniques but with the added benefit of the net-shaped fabrication that AM allows.

Functionally graded metal alloys have been demonstrated previously using the LENS® process but the technique has