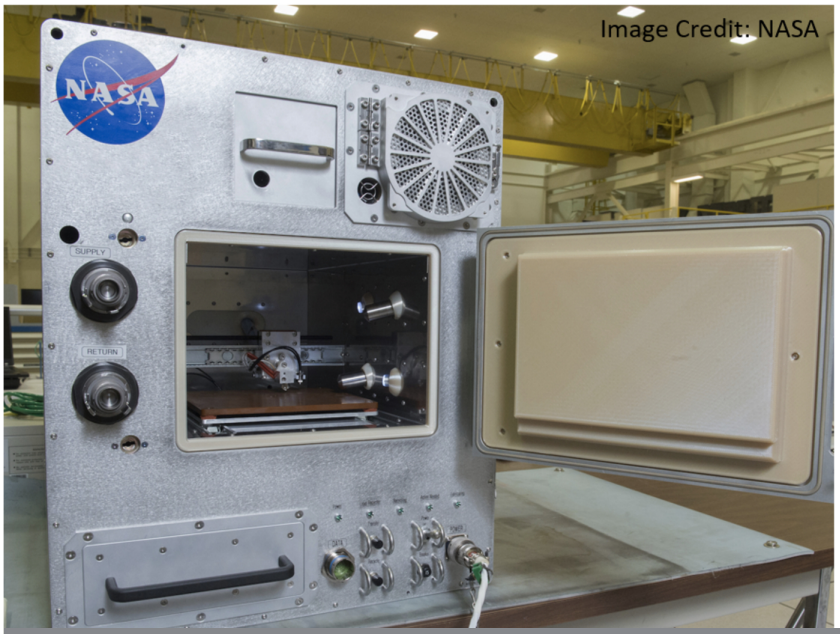


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Manufacturing

Recyclable Feedstocks for Additive Manufacturing

On-Demand Article Fabrication with Polymer-Coated Epoxy Microparticles

Innovators at the NASA Langley Research Center have developed a manufacturing technique to generate recyclable feedstocks for on-demand additive manufacturing. Additive manufacturing is a rapidly advancing art with significant recent improvements in starting materials. One common limitation has been that produced articles cannot be recycled without substantial energy costs. Development of a manufacturing technique that can generate precise, mechanically robust articles that could be reverted to feedstock for use in subsequent article manufacturing would be highly desirable for applications including long duration extra-terrestrial exploration mission planning. NASA's new manufacturing technique uses polymer-coated epoxy micro-particle systems as a recyclable feedstock material that can be used not only for in-space additive manufacturing during long-term human spaceflight but also for a wealth of applications on Earth. The resulting articles are more chemically and mechanically robust compared to the state-of-the-art materials used for most 3D printing applications.

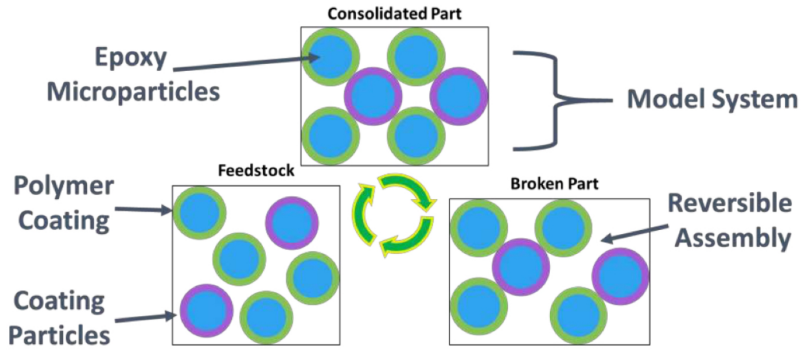
BENEFITS

- Recyclable feedstock: materials can be "un-clicked" at elevated temperatures, enabling a return to feedstock for subsequent fabrication of a new part
- Tunable properties: materials could be used to generate feedstock for 3D printing applications that have tunable thermal and mechanical properties for various applications including processing in facilities as simple as a home kitchen (i.e., hot water)
- Robust material: the composition is derived from the urethane and carbonate containing species, so parts created from the feedstock would be much more chemically and mechanically robust compared to the state-of-the-art ABS and PLA materials used for most 3D printing applications

THE TECHNOLOGY

NASA's new technique for generating recyclable feedstocks for on-demand additive manufacturing employs the high-yield reversibility of the Diels-Alder reaction between maleimide and furan functionalities, utilizing the exceedingly favorable interaction between specific chemical functionalities, often termed "click reactions" due to their rapid rate and high efficiency. Integration of these moieties within a polymer coating on epoxy microparticle enables reversible assembly into macroscopic, free-standing articles. This click chemistry can be activated and reversed through the application of heat. Monomer species can be used to incorporate these functionalities into polyimide materials, which provide excellent mechanical, thermal, and electrical properties for space applications. Copoly (carbonate urethane) has been shown to be a viable coating material in the generation of polymer-coated epoxy microparticle systems and is amenable to being processed through a variety of approaches (e.g., filaments and slurries for 3D printing, compression molding, etc.). The polymeric materials are grown from the surfaces of in-house fabricated epoxy microparticles. The thermal and mechanical properties of the microparticles can be readily tuned by changes in composition.

There are a number of potential applications for this NASA technology ranging from use of these materials for recyclable/repurpose-able articles (structural, decorative, etc.) to simple children's toys. More demanding uses such as for replacement parts in complex industrial systems are also possible. For long term space missions, it is envisioned that these feedstocks would be integrated into secondary spacecraft structures such that no additional concerns would be introduced due to in-space chemical reactions and no additional mass would be required.



Components of NASA's Recyclable Feedstocks for Additive Manufacturing technology. Image Credit: NASA

APPLICATIONS

The technology has several potential applications:

- Aerospace: in-space additive manufacturing techniques to enable on-demand generation of mission-critical articles (tools, infrastructure, etc.)
- Composites: creation of materials with tunable thermal and mechanical properties
- Consumer goods: reversible 3D printed parts that can be processed in simple facilities
- Manufacturing: recyclable feedstock for additive manufacturers
- Military: in-field generation of tools for military operations
- Oil and gas: replacement parts for oceanic oil drills
- Power: replacement parts for wind turbines

PUBLICATIONS

Patent No: 11,649,337; 11,820,866

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NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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