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LASER SINTERING DEVELOPMENT FOR DIRECT INK WRITE MATERIALS FOR PRINTED ELECTRONICS MANUFACTURED IN SPACE

Abstract

Additive manufacturing allows for the on-demand production of electronic devices in space, reducing the cost and time requirements for replacing necessary parts. The on-demand electronics manufacturing process involves printing nanoparticle inks on a desired substrate using modalities such as inkjet, aerosol jet, plasma jet, screen, and direct ink write printing. However, printing devices in space requires additional considerations, such as the lack of gravity. Direct ink write printing extrudes ink directly onto the substrate without requiring gravity to properly administer the ink. For this reason, direct ink writing is studied in this work as a potential printing method for in-space manufacturing. Once the ink is deposited on the substrate, a sintering step is required to achieve the desired circuit properties, accomplished through thermal, chemical, or UV exposure. NASA Marshall Space Flight Center aims to produce printed electronics on the International Space Station (ISS) as part of its mission to achieve in-space on-demand manufacturing of electronics, or ODME. The ISS is limited to power and space requirements, making the search for an alternative efficient and viable sintering method necessary. Laser sintering uses a laser to fuse nanoparticles and evaporate solvents and binders within the ink. This work examines the possible laser wavelengths, pulse durations, power, and scanning speed to make laser sintering feasible for various materials for ODME in space. Achieving the proper adhesion, electrical properties, and device structures is an essential aspect of this research in pursuing the ODME mission, along with the sustainability and efficiency of manufacturing in space as the primary motivation for this work. Materials studied include silver, silver-palladium, and barium titanate on glass, polyimide, and alumina substrates. The continuous wave laser wavelengths investigated are 445 nm, 808 nm, 915 nm, and 1064 nm. The pulse durations considered include femtosecond and picosecond range. Overall, the continuous wave 445 nm laser system has proven to be the most capable laser system for sintering printed electronics on the ISS.