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DEMONSTRATION OF IN-SPACE SOLID-STATE JOINING OF DISSIMILAR AEROSPACE ALLOYS USING NANOSTRUCTURED INTERLAYERS

Abstract

This study proposes a novel in-space solid-state joining technique for dissimilar metals—SS321 stainless steel and AA2219 aluminum alloy—commonly used in aerospace, defence, and nuclear sectors. Traditional methods face challenges including brittle intermetallic formation and thermal mismatch. To address this, a hybrid joining process employing nanostructured interlayers was developed to enhance diffusion, minimize intermetallics, and improve thermal compatibility. Simulated microgravity trials via parabolic flights and thermal-vacuum chambers demonstrated high mechanical strength, joint integrity, and oxidation resistance. A technology demonstration aboard the International Space Station (ISS) is proposed using a miniaturized autonomous module to execute and monitor the joining process in real-time, capturing data on interfacial temperature, stress, and phase evolution. This system supports in-orbit manufacturing, repair, and modular assembly, reducing mission costs and increasing flexibility. The validated method also holds strong terrestrial potential, offering cross-sector benefits. This research lays the foundation for scalable in-space fabrication and sustainable deep-space mission capabilities.