Materials Science and Engineering Thesis Defense

Solid-State Diffusion Bonding Inconel 718 to Itself for Sheet Laminate Additive Manufacturing

School for Engineering of Matter, Transport and Energy

Reggie Angell
Advisor: Leila Ladani

Abstract

Transient liquid phase diffusion bonding is a common process used to join stacked laminates for the sheet lamination additive manufacturing process. The joining process implements interlayer materials that contain melting point depressants (MDP) which alleviate some production challenges and aid in the bonding process. While this thin interlayer material assists some of the challenges associated with production, it also introduces new elements into the base material. This contamination can reduce the solidus temperature of the base material and affect subsequent production processes. Solid-state diffusion bonding, without the aid of an interlayer material, can offer similar results to transient liquid phase diffusion bonding without contaminating the base material. However, bonding in the solid-state adds production challenges associated with the laminates' surface finish and the accompanying higher-pressure levels required to achieve intimate contact between substrates. Omitting interlayer materials also removes any concentration gradient, which gives the net flux of diffusing atoms direction of flow. Without a concentration gradient, the process must largely rely on the random walk theory. Iterative experiments were conducted using Inconel alloy 718 substrates bonded in a Centorr vacuum furnace hot press at various super solvus temperatures, pressures, surface roughness, and hold times. All samples were processed with an AMS2774 condition S1750DP heat treatment after the bonding process to precipitation harden the solid-state bonded material. To characterize the results of the experiments, samples were subjected to metallographic, scanning electron microscope, Vickers microhardness, and room temperature tensile testing. Results of the experiment show that diffusion bonding alloy 718 at super solvus temperatures without the aid of an interlayer material is possible but results in low yield strength, relative to the base material. This low yield strength is due to large grains as a result of the super solvus diffusion bonding process. Large Niobium rich carbides and Titanium rich nitrides were present throughout all samples and were considerably larger in samples bonded above 1200°C. It is theorized that the large NbC and TiN precipitates could have depleted the bulk of valuable precipitation forming elements, resulting in less precipitation hardening on bonded samples with large precipitates.

October 10, 2025; 12:00pm; ISTB4 492

Arizona State University