Adhesion strength of adhesively and ultrasonically bonded Ti-Al laminated composites under high-strain rate laser shock loading

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Relevant Working Groups: WG5

Objectives / Description / Main outcomes

Within this STSM the collaborative works have been carried out to investigate in detail the dynamical material response (DMR) of bonded, 5-bilayered Ti-Al laminated metal composites (LMCs) under high strain laser shock loading (~10^7 s^{-1}). Laser shock impacts were obtained by high intensity, nano-second Nd:YAG laser, operated at 532 nm. DMR of bi LMCs was monitored by the back face velocity (BFV) measurements via LAser Shock Adhesion Test (LASAT), using the advanced laser system and VISAR (Velocity Interferometer System for Any Reflector) experimental equipment (Fig. 1). Based on the initial literature survey of the current-state-of-the-art (SOTA), preliminary tests and narrow engineering technological window the peak pressure (P_{max}) of the laser shocks has been defined, ranging from ~ 1.5 to ~ 2.5 GPa. The pressure P_{max} was controlled by the laser power intensity (~ 2.0 to ~ 6.0 GW/cm^2), whereas pulse duration and spot diameter was kept constant. LASAT dynamic loading experiments were performed "*outside the line - OUT*" and "*on the line - ON*" (sonotrode edge -> highest contact stress) to establish the correlation between process parameters, joint strength, and determine location of the "weakest link" within the material.

The "*in-situ*" DMR monitoring by the BFV measurements and additional "*post-mortem*" characterization confirmed the location of the "*weakest link*" within the LMCs and the possibility for joint disassembly and re-use purposes of dissimilar hybrid components. Simulation of the laser-imposed shock wave propagation by 2D axisymmetric model and Johnson-Cook material model have confirmed good correlation with experimental results (Fig. 2). In addition, we confirm that despite similar thickness of the LMCs ON & OUT regions, the latter exhibit much higher damage tolerance against debonding (Fig. 2) This demands 3 - times higher laser power density & 1.73 - times higher peak pressure (6 *vs.* 2 GW/cm^2 & 2.45 *vs.* 1.41 GPa) for debonding to occur.

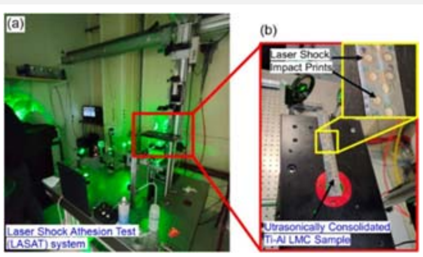

Figure 1: *LASAT and (b) laser shock impacts on UC Ti-Al LMC sample*

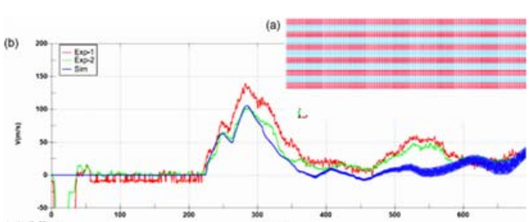

Figure 2: *(a) 2D Axisymmetric model of the Ti-Al LMC used for shock wave simulation, (b) experimental and simulation BFV profiles at 2 GW/cm^2.*

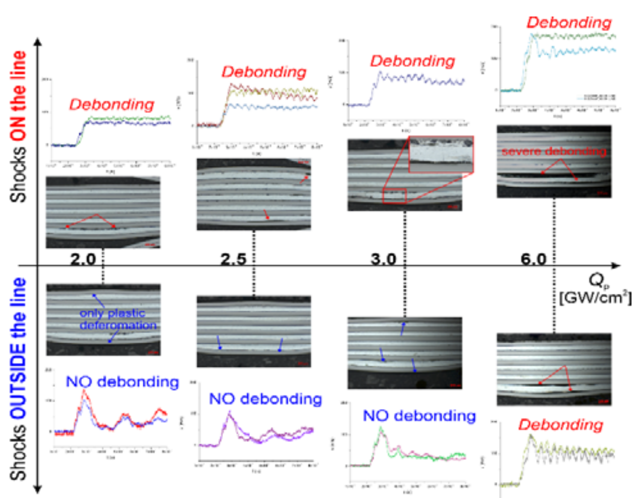

Figure 3: *BFV measurements with the corresponding cross-section microstructural results.*

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