3. Results and Discussion

3.1. TLP ~~microstructures~~Microstructures

The optical image of the TLP bonding area in brazed sample at 1100˚C for duration of 15 minutes is shown in Fig. 1. As can be observed, the bond region is composed of three distinct zones including the ~~athermally~~ Athermally ~~solidified~~ Solidified ~~zone~~ Zone (ASZ), ~~isothermally~~ Isothermally ~~solidified~~ Solidified ~~zone~~ Zone (ISZ), and ~~diffusion~~ Diffusion ~~affected~~ Affected ~~zone~~ Zone (DAZ). The ISZ microstructure consists of proeutectic γ solid solution phase. ~~Microstructure~~ The microstructure of the ASZ consists of ~~microconstituents~~micro constituents with eutectic-like morphology, which indicates non-isothermal solidification.

3.1.1. Microstructural ~~evolution~~ Evolution in ASZ

Fig. 2 demonstrates secondary and backscattered electron micrographs of the ASZ microstructure. Moreover, Table 2 reveals semi-quantitative SEM chemical composition~~al~~ analysis of the phases within the eutectic using ~~electron~~ Electron ~~dispersive~~ Dispersive ~~spectroscopy~~ Spectroscopy (EDS), which suggests them as ~~nickel~~Nickel-based ~~solid~~ Solid ~~solution~~ Solution ~~phase~~Phase, ~~nickel~~Nickel-rich ~~boride~~Boride, ~~chromium~~Chromium-rich ~~boride~~ Boride, and ~~nickel~~Nickel-rich ~~silicide~~Silicide. Typical EDS spectra of these phases ~~are~~ is given in Fig. 3 (a-d). Due to ~~the~~ X-~~ray~~ Ray absorption, boron could not be quantified by EDS analyzer window. XRD analysis was used to identify the constituting intermetallic compounds. Fig. 4 shows the XRD spectrum, which was ~~achieved~~ obtained from the shear fracture surface of the joint ~~made~~ formed at 1100˚C for duration of 15 min. The XRD pattern ~~demonstrated~~ demonstrates the peaks of Ni solid solution (γ phase), $M_{23}B_6$ (~~nickel~~Nickel-rich ~~boride~~Boride), and CrB boride. Other researchers have reported similar eutectic microstructure in the centerline of TLP bonded ~~nickel~~Nickel-based alloys. For instance, Ohsasa et al. studied numerical modeling of transient liquid phase bonding of Ni substrate using an Ni-Cr-B filler alloy and reported the formation of a ternary centerline eutectic product, which consisted of an Ni-based solid solution phase (γ), ~~nickel~~ Nickel boride (Ni_3B) and ~~chromium~~ Chromium ~~boride~~ Boride (CrB) in the bonding zone. They also proposed that the eutectic reaction, $L \rightarrow \gamma + Ni3B + CrB$ ~~$L \longrightarrow \gamma + Ni_3B + CrB$~~, would occur while cooled down to 997˚C. Additionally, an experiment was conducted on microstructural development in TLP bonding of IN-738LC ~~superalloy~~super alloy using a Ni-Si-B interlayer by Mosallaee et al.~~,~~ who observed the formation of a centerline eutectic product that ~~which~~ consisted of ~~nickel~~a Nickel-based solid solution, Ni-rich ~~boride~~ Boride, and Ni-rich ~~silicide~~ Silicide in a sample joint at 1100˚C for duration of ~~1 min~~one minute.

Two inter-related solidification phenomena, called dendritic formation and solute partitioning, can control the development of microstructure in the ASZ. ASZ microstructure can be explained ~~Considering~~ due to the fact that general direction of solidification is from the base alloy toward the centerline region of the melt~~,~~. ~~ASZ microstructure can be explained~~. The γ phase is the initial solid phase formed during cooling in this region as the dendrites ~~which~~ grow from liquid/solid interface ~~is the initial solid phase formed during the cooling in~~

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Eutectic zone, : [1] Comment [SMM Eutectic Morphology?