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Persuade Of Development Parameters on Diffusion Coupled Joints of Dissimilar Materials –An Analysis

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Abstract: Diffusion bonding method is an alternate technique to join like and unlike materials with minimum dimensional tolerance. It is the solid state process in which two metallic surfaces are made to contact at the elevated temperature and pressure. Diffusion bonding process provides high eminence joints without post weld machining. The main process parameters of diffusion bonding embrace temperature, pressure and holding time. It is significant that the metallic surfaces should be spotless and free from oxides and nonmetallic films. In diffusion bonding technique microstructural changes were formed in the base metal which determines the mechanical properties of the bond at the interface. Diffusion bonding method can be used to weld the dissimilar materials with different chemical and mechanical properties. The present work reviews the influence of process parameters on diffusion bonded joints of dissimilar materials in the midst of and with no interlayer. Examination on the microhardness, lap shear and microstructure were made for various dissimilar diffusion bonded joints and finally some general conclusions are summarized.

Keywords: Titanium Alloy, Stainless Steel, Diffusion Bonding, Microhardness, Microstructure, Lap shear.

1. INTRODUCTION

Diffusion bonding is a solid state joining process in which two clean metallic surfaces are brought into drop a line to at elevated temperatures under low pressure [1, 2]. .Diffusion bonding produces high-quality joints without post weld machining [3]. Diffusion bonding quality joints can be done with or without the give support to of interlayer. In order to produce a high-quality joint by diffusion bonding, the two contact surfaces should be even, which increases the atomic diffusion path between the surfaces [4, 5]. Similar and dissimilar materials can be coupled by diffusion bonding technique. To produce metallurgical joint between the dissimilar metals higher bonding temperature and longer holding time are needed for fast interdiffusion rate between the materials [6]. In this present work, various dissimilar diffusion bonded joints process parameters and their influence in lap shear, microhardness, microstructure were analysed.

2. PROCESS PARAMETERS THAT INFLUENCE THE DIFFUSION BONDING

2.1 Effects on hardness and lap shear

Ozdemir et al. bonded Ti-6Al-4V and AISI 304 stainless steel with copper as an interlayer. They conducted diffusion experiment at three poles apart temperatures of 800˚C, 900˚C and 1000˚C, at three different holding times for 50,100 and 150 min at 1MPa. The outcome revealed that an extensive increase in hardness of 304L stainless steel adjacent to cu interlayer and there is a sudden increase in the hardness of Ti-6Al -4V /Cu interface due to the formation of intermetallic at the Ti lattice. This is due to amplifying in temperature and holding time. They also found that at stumpy joining temperature and holding times the bonding strength is lower due to incomplete coalescence of the mating surfaces. The highest strength of 118Mpa was obtained at 870˚C at 90 min holding time.Copper interlayer between the materials improves the joint quality thereby avoiding voids formation at the interface [7].

LiuHuijie et al. bonded TC21 titanium alloy with a dimension of 10mmx10mmx2mm with a vacuum degree of 6.6x10^{-3} Pa to a temp ranging from 780˚C to 980˚C under 10MPa for 5min to 90min. They have pragmatic that microhardness value increases from 3480 MPa to 3560MPa when the bonding temperature increases from 930˚C to 980˚C for a time period of 60min. When bonded for 90min the microhardness decreases slightly [8]. Vigraman et al. bonded Ti-6Al-4V and AISI 304 L at a temperature ranging from 875˚C -950˚C at a bonding time of 60 min with a holding pressure set of 4MPa and 8MPa. They found that the maximum microhardness value of 378.6VHN was obtained for the sample bonded at 950˚C, 8Mpa, and 60 min. The hardness value is maximum at the boundary. The maximum tensile strength of 144.7MPa was obtained for the sample bonded at 900˚C, 4Mpa with 60min holding time[9].

Torun et al. bonded AZ91 with silver interlayer at 480˚C of 0.5, 1 and 2 hr with 1MPa.They observed that for all bonding time there is no noteworthy variation and the microhardness ruins same at the interface and almost same as that of base metal AZ 91. Hardness value is almost same at the interface and is about 70Mpa and increasing the holding time to 1 hour does not cause any significant deviation in the shear strength [10].

Evren et al bonded commercially pure titanium to low carbon steel with silver as an interlayer with the temperature ranges from 700˚C to 850˚C with a holding time 30, 60, 90 and 120 min under 3MPa. The hardness value of about 450HV was experimental for the diffusion bonded couples at 850˚C under 3MPa. When hardness values deliberate at the interlayer of the bonded specimen and compared to each other, they found that hardness increases with escalating temperature. At the 700˚C temperature and 90 min holding time under 3MPa, the shear strength was 1415.7N. The highest tensile strength was established to be 3222.8N for the specimen bonded at 850˚C for 90 min. The lowest strength obtained was 1077.9N at 700˚C for 120min [11].

Peng et al. bonded Mg & Al to the temp ranging from 450˚C to 490˚C at a pressure 0.08 to 0.1 MPa with a holding time from 40 to 60 min. They observed that the microhardness ranges from 260HV to 350HV depending upon the location of the diffusion zone. It was also discovered that Mg-Al intermetallic compounds of high hardness and brittleness created in the diffusion zone [12].

Verter et al bonded zirconia and silicon nitride with nickel as interlayer under pressure at 14MPa and 37MPa and at temperatures 900˚C and 1275˚C with 30 min holding time. Maximum strength was obtained in the range of 1000˚C-1100˚C. Most of the welds disastrous at silicon nitride – Nickel interface, as the strength of the bond is chiefly resolute by the phenomena occurring at the interface.[13]. Viagra man et al bonded AISI 304 L steel and low carbon steel with AISI 304 steel as an interlayer. The temperature ranges from 850˚C to 950˚C with 90min holding time under 10MPa. They have observed the greatest hardness value of 340.5MPa was obtained at the center of the interlayer. At 950˚C the strength of the joint is decreased due to grain coarsening of the base metal. The highest hardness value of about 402.2VHN is obtained at the interface of low carbon steel to the interlayer.[14]

2.2 EFFECTS ON MICROSTRUCTURE

Wang et al bonded Fe_3Al and low carbon steel Q235 at 1333k for 60 min under 15MPa in a Vaccum pressure of $4.5X10^{-5}$ Pa. They observed that there is a communal diffusion between the materials and interface transition Zone is formed between Fe3Al and steel. The measurement of Fe3Al/Cr18Ni8 interface zone is 35µm. [15]

Kemal et al. bonded Ti-6Al-4V and copper at various temperatures of 875˚C, 890˚C and 900˚C, and times of 15, 30 and 60 min at a pressure of1MPa.They pragmatic that the phase zone thickness increases when the holding time increases at the same temperature. In totaling to that various phases of Cu-Ti intermetallic compounds are formed at the interface.[16]

Ren Jiangwei t al. bonded Ti and Aluminium at a temperature of 640˚C, 90 min holding time with a pressure of 24MPa.They observed the new phases are fashioned at the interface zone.TiAl3 intermetallics are created specifically when the Al content is 60-64%.Also revealed that the maximum solubility of Ti in Al is 0.26 -0.28% when the temp is at 665˚C.[17]

Peng He et al. bonded Titanium alloy and stainless steel 18Cr10Ni with Nickel interlayer of 30µm thickness at a mixture of temperature ranging from 750 to 910 C with a holding time 5 to 30 min at.15MPa.They saw that seen that a certain amount diffusion occurs between the interlayer and the parent metal and new-fangled phases formed at the interface. Also observed that the diffusion distance from the Ni to Ti alloy is long which indicates that a metallic compound film is formed by the diffusion. Layer. Diffusion layers are wider with an increase in temperature [18].

TC21 titanium alloy with a measurement of 10mmx10mmx2mm was used for diffusion bonding the heating process determines the microstructure development of the diffusion bonded joint (9). Liu Huijie et al observed that at 980˚C the phases transforms into β phases and when chilled α phase nucleates at the β grain boundaries. When bonded beneath 930˚C with a 30min holding time equiaxed structure is obtained. [8].

Peng Liu et al bonded Mg & Al at high temperature in the diffusion reaction process stuck between Mg and Al, the macroscopical transplant was twisted between the two substrate atoms. Three new phase layers are formed in the diffusion zone of Mg/Al bonded joints.[12]

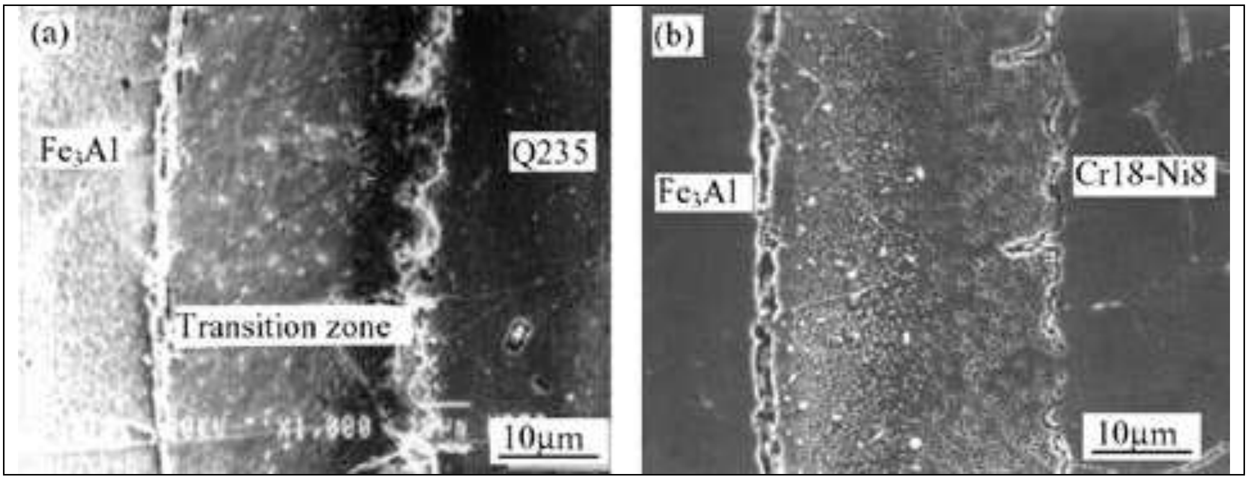

Fig (a) Fe3Al/Q235 **Fig (b) Fe3Al/Cr18–Ni8**

Fig 1(a &b) Microstructure at the Fe3Al/steel diffusion bonding interface. Adapted from [15]

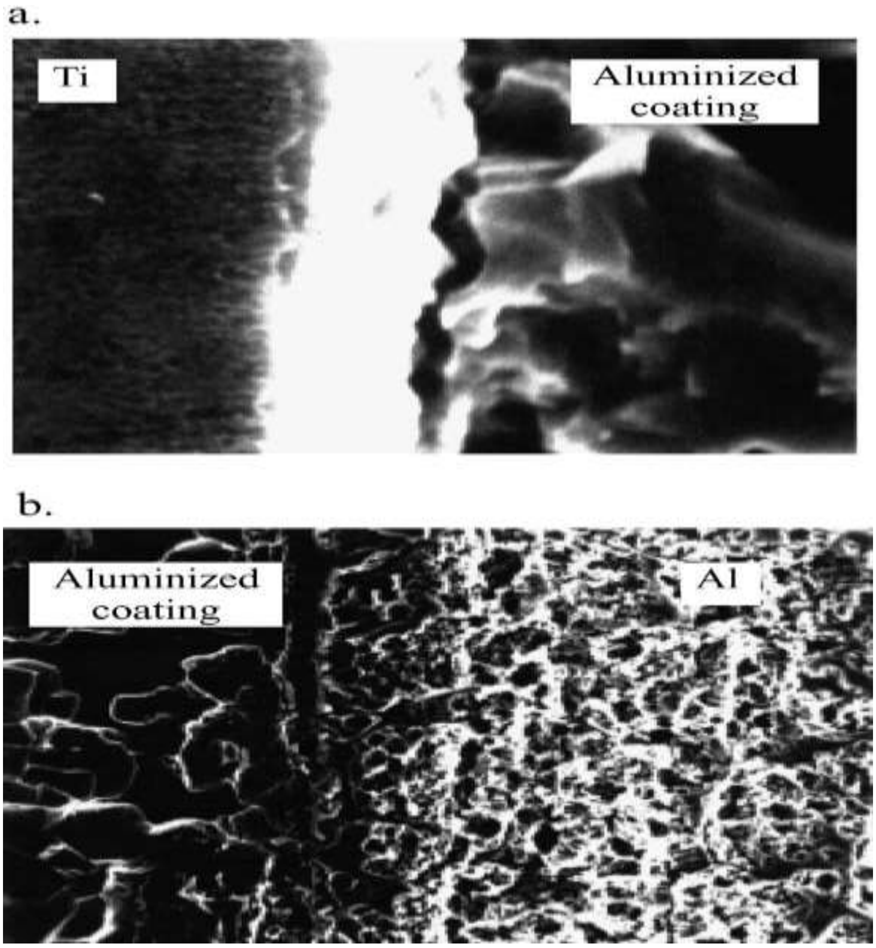

Fig 2(a &b) Microstructure in interface zone of Ti/Al diffusion bonding (SEM). (a) Transition zone on Ti substrate, 5000X (b) Transition zone on Al substrate, 300X Adapted from [17]

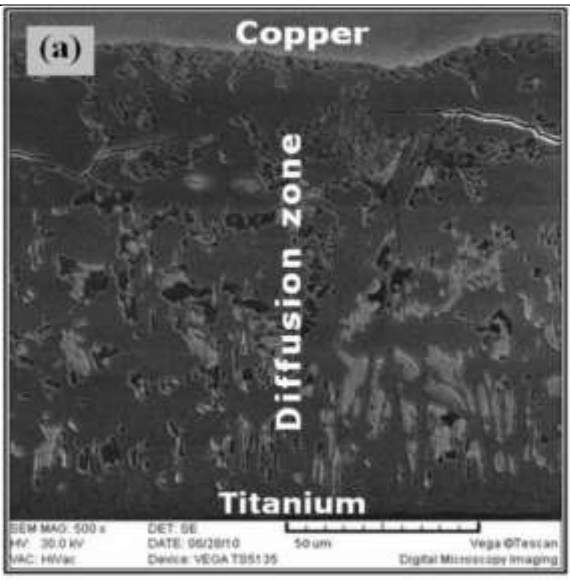

Fig 3: Microstructure of the Ti-6Al-4V –Cu diffusion Bonded Couples .Adapted from [16]

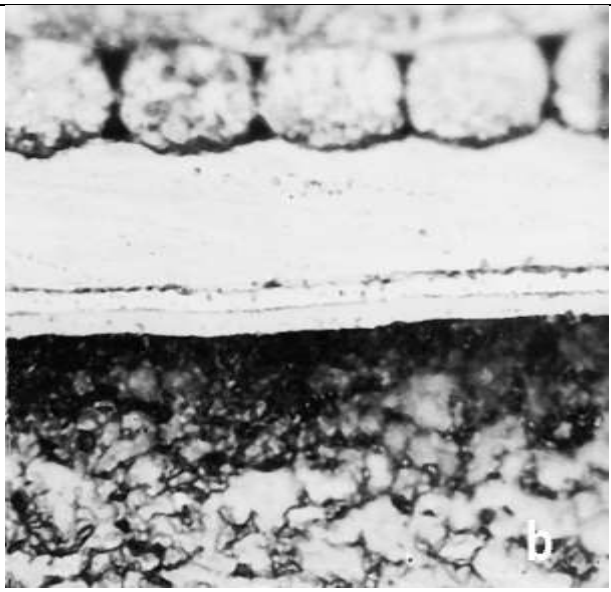

Fig 4:Optical microstructure of bond joint (P- 15MPa, t-15min Temp 580C) Adapted from [18]

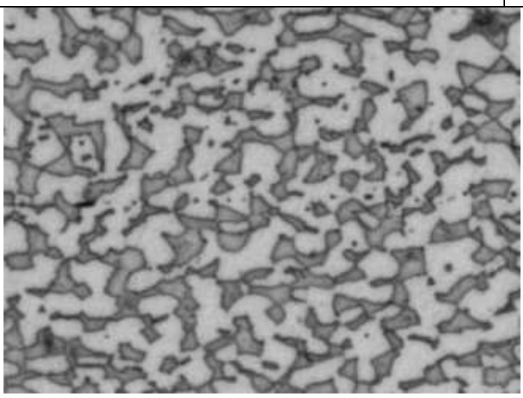

Fig (a) 830 ˚C

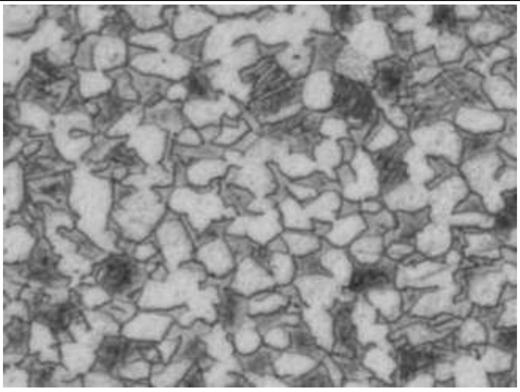

Fig (b)) 880 ˚C

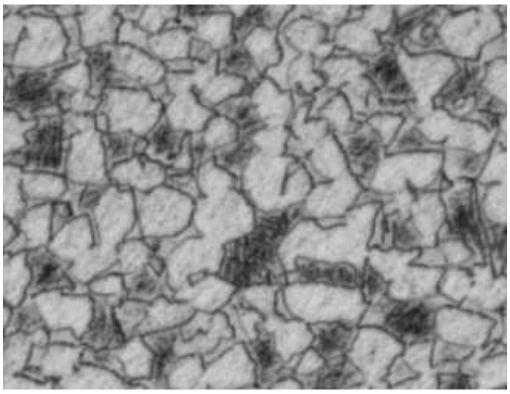

Fig (c) 930 ˚C

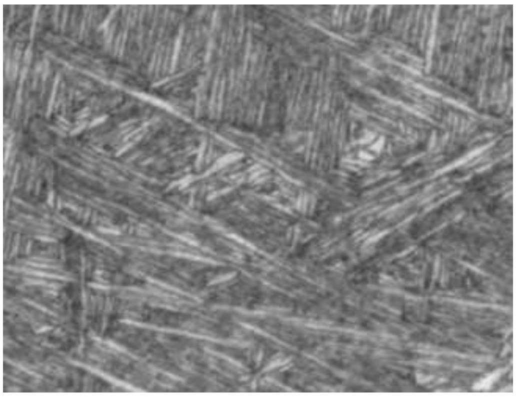

Fig (d) 980 ˚C

Fig 5(a-d) Interface morphologies of joints bonded at different temperatures (*t* =30 min). Adapted from [8]

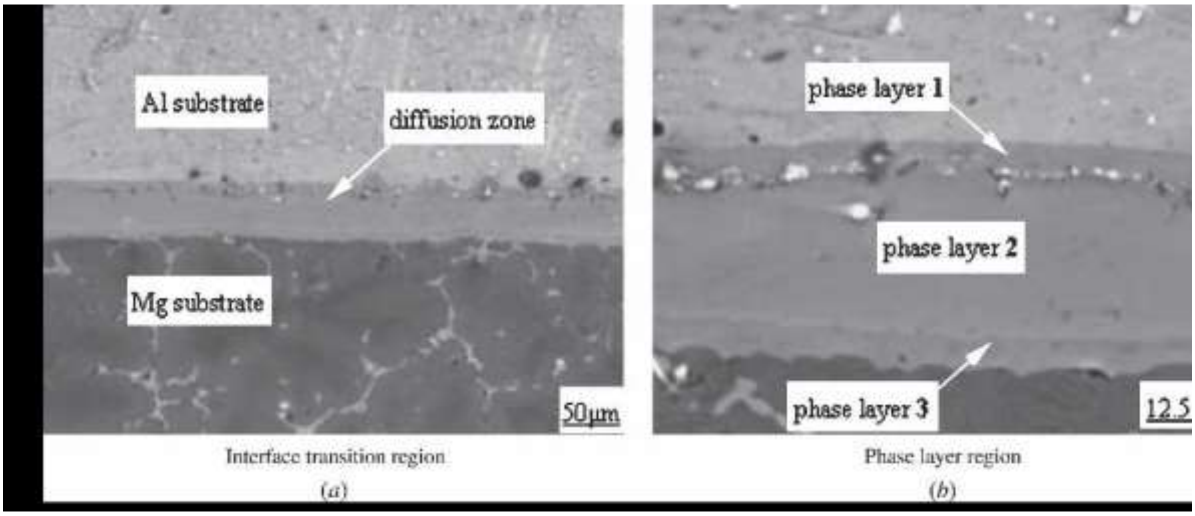

Fig.6.The microstructure near the interface zone of Mg/Al diffusion bonding Adapted from [12]

3. CONCLUSION

Based on the above discussions the following results can be drawn.
The tensile strength of the diffusion bonded couples increases with temperature, highest hardness can be obtained at the diffusion layer as that of the parent metal. Grain growth increases considerably in the bonded couples due to increase in the temperature. Diffusion area increases with increasing time and temperature. Bonding pressure and the thickness of the interlayer does not affect the bonding strength.

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