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Microstructures in Friction-Stir Welded Dissimilar, Semi-Solid-Cast Magnesium Alloys

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Friction-stir welding (FSW) is a solid-state welding technique involving severe plastic deformation of the material being welded, when a rotating tool is fed through a joint to be welded. Semi-solid-cast magnesium (Mg) alloys contain a primary solid fraction (un-melted alloy fraction) of α-Mg globules in a eutectic matrix of α-Mg grains, surrounded by $Mg_{17}Al_{12}$ intermetallic grains in the α-Mg grain boundaries. The joining of the material by FSW is facilitated by dynamic recrystallization of the base material, producing a homogenous, equiaxed, fine-grain structure in the weld zone. There is also no degradation of the residual microhardness of these Mg alloys when they are friction-stir welded. [1-3]

This research involved the FSW of thin plates (~1.8 mm) of semi-solid-cast Mg alloys AZ91D (solid fractions of 5% and 23%) and AM60 (solid fractions of 2% and 18%). All plates were welded with a tool rotational speed of 2000 rpm and a traverse speed of 2 mm/sec. One observes a clear decrease in grain size from the base material (figure 1B) through the transition zone (figure 1C) and into the FSW zone (figure 1D). The complex grain structure of the base material is dynamically recrystallized to a homogenous, equiaxed, fine-grain structure. There was also no degradation of residual microhardness of the material in the FSW zone or the transition zone.

Figure 1A shows the advancing and retreating sides of the FSW of AZ91D (23% solid fraction) with AM60 (18% solid fraction). One sees a clear demarcation in the advancing side (AZ91D) and a diffuse flow into the retreating side (AM60). This pattern is observed in all the welds with dissimilar materials that have the AZ91D in the advancing side. Figure 1B shows the microstructure of one of the base materials (AZ91D (23% solid fraction)), where we see the primary solid fraction globules in the α-Mg eutectic matrix. Figures 1C and 1D show the recrystallized grain structure in the transition and FSW zones respectively. Figures 2A and 2B show precipitates of $Mg_{17}Al_{12}$ in the weld zone, and dislocation structures within the grains from the TEM analysis of the weld zone of the FSW of AZ91D (5% solid fraction) with AM60 (2% solid fraction) and AZ91D (23% solid fraction) with AM60 (18% solid fraction) respectively.

References

[1] L. E. Murr et al., Journal of Materials Science (2003) in press.
[2] F. Czerwinski et al., Acta mater. 49 (2001) 1225-1235.
[3] J. A. Esparza et al., Journal of Materials Science Letters 21 (2002) 917-920.
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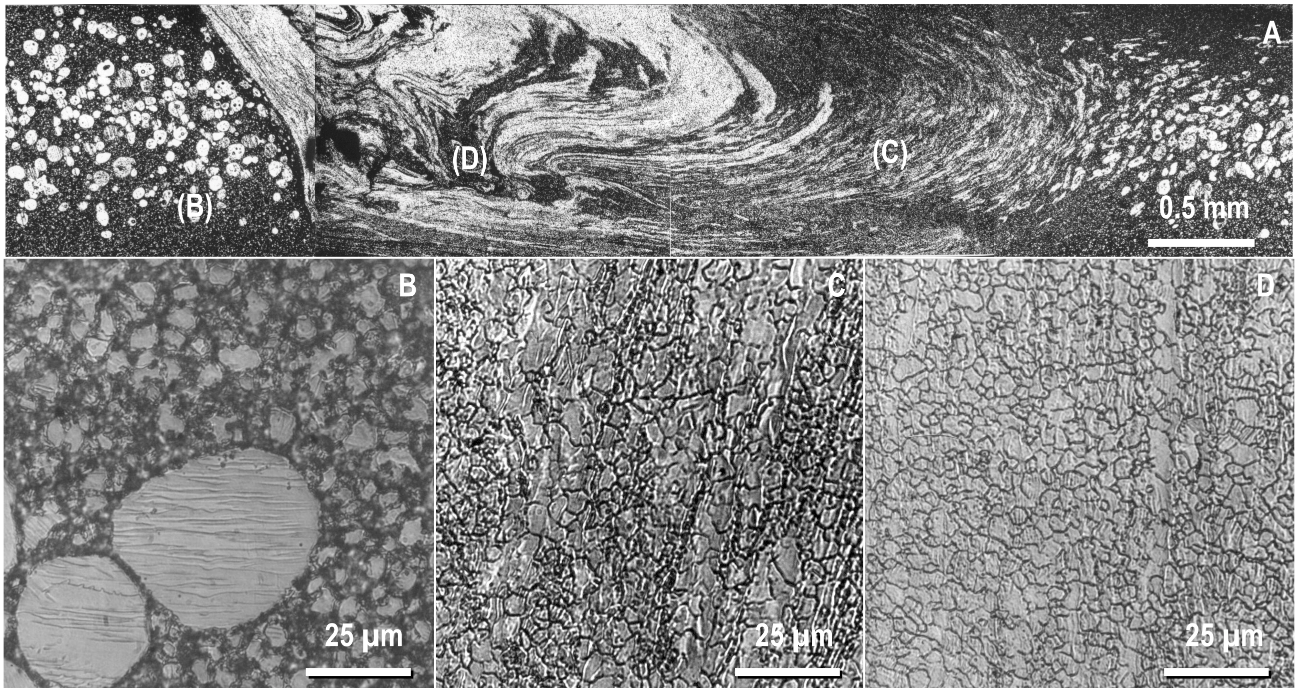

Figure 1: (A) Advancing and retreating sides of the FSW of AZ91D (23% solid fraction) (advancing side) with AM60 (18% solid fraction) (retreating side) (B) AZ91D (23% solid fraction) base material (C) Transition zone (D) FSW zone

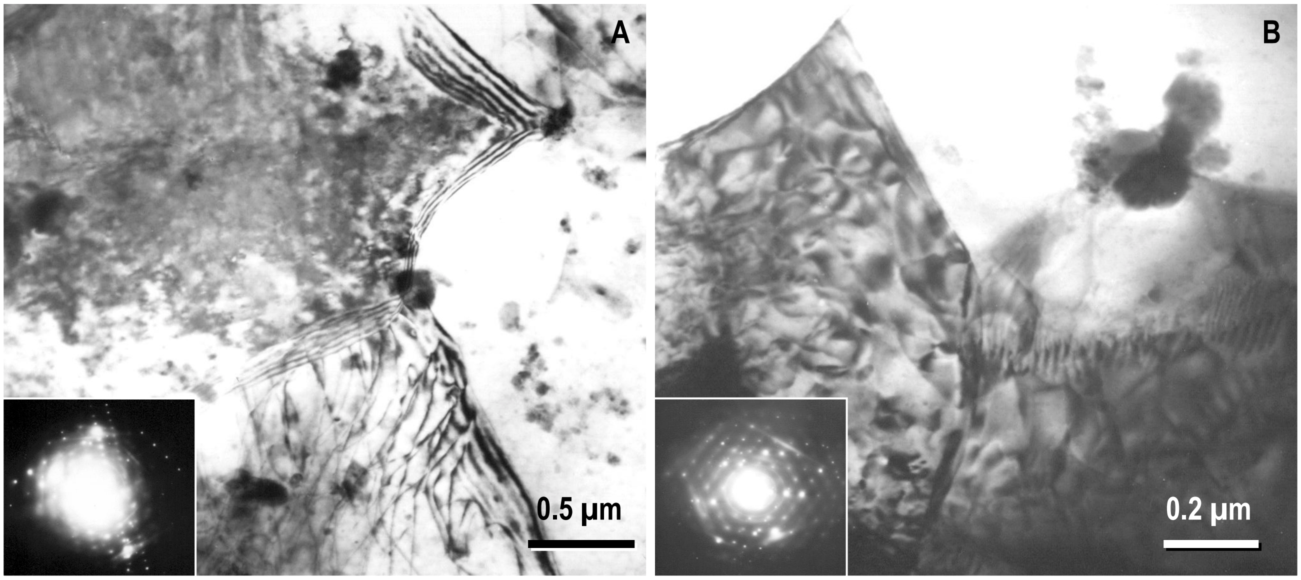

Figure 2: (A) TEM image from the weld zone of the FSW of AZ91D (5% solid fraction) with AM60 (2% solid fraction) showing dislocation structures within the grains and precipitates of $Mg_{17}Al_{12}$ (B) TEM image from the weld zone of the FSW of AZ91D (23% solid fraction) with AM60 (18% solid fraction) showing dislocation structures and moiré fringes within the grains and a precipitate of $Mg_{17}Al_{12}$