Texture, microstructure, and property evolution during warm accumulative roll bonding to produce Ti-Al4Mg nano-metallic-laminates

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Abstract

Accumulative roll bonding (ARB) is a severe plastic deformation (SPD) manufacturing process capable of producing engineering-scale quantities of nano-metallic laminates (NMLs). We have recently developed a warm-ARB (WARB) processes to successfully produce NMLs using the reactive metal combination of Ti and Al-4%Mg. The evolution of texture, microscostructure, and mechanical properties with processing was measured using EBSD, TKD, TEM, and micro-mechanical testing. The SPD rolling process results in rapid reduction of Ti grain size to sub-μm scales due to activation of multiple twinning modes and multiple generations of twinning. In addition, continued ARB processing results in evolution of the Ti basal poles towards the plate transverse direction (TD) with the peak in intensity occurring in the TD. The Ti-Al4Mg NML with 50nm average layer thickness exhibits GPa strengths, and the strong basal texture in the TD results in significant in-plane strength anisotropy. During the WARB process, the Al4Mg layers dynamically recrystallize throughout the process allowing Al4Mg to maintain continuous work hardenability. The WARB Ti does have a slightly larger average grain size and somewhat smaller GND content as measured by EBSD, resulting in a reduction in hardness relative to cold ARB processed Ti. These factors promote co-deformation during processing allowing layer fragmentation to be avoided.

Keywords: Titanium, Accumulative Roll Bonding, Severe Plastic Deformation, EBSD, TEM, TKD, micro, mechanical testing, nano, metallic laminate

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