

Positron annihilation spectroscopy study of gradient microstructure induced by Surface Mechanical Attrition Treatment (SMAT) in Mg

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Surface mechanical attrition treatment (SMAT) was used to generate a gradient microstructure in commercial-grade magnesium. The SMAT is based on surface plastic deformation induced by repeated impacts on the treated surface with high-velocity spherical shots of a few millimeters in diameter. Multidirectional impacts induce grain refinement to the nanometer scale at the target surface. SMAT was performed in the stainless-steel chamber at room temperature in air using 2 mm diameter stainless steel balls and a vibration frequency of 20 kHz, for 60 s and 120 s with twice the vibration amplitude. The normal speed of shots depends on the vibration amplitude, i.e. increase in the amplitude leads to a higher impact velocity. Doubling the vibration amplitude leads to doubling the velocity of shots and hence their kinetic energy rises approximately fourfold.

Positron annihilation spectroscopy measurements, X-ray diffraction, polarized light microscopy, electron backscatter diffraction, microhardness tests, and electrochemical corrosion tests, were used to investigate the created subsurface.

It was found that SMAT causes an increase in dislocation density and grain refinement. The values of the positron lifetime point out trapping of positrons in vacancies associated with dislocations and dislocation jogs. The longer processing time and the higher energy imparted to the sample surface during longer SMAT with the higher vibration amplitude caused the appearance of the plateau of positron lifetimes values up to the depth of about 200 μm . For both samples, the value of the mean positron lifetime decreases with the depth and reaches values for the reference sample indicating the end of SMAT induced region at the depth of about 800-900 μm .

Electrochemical corrosion tests revealed that the structural changes induced by SMAT increased the susceptibility of magnesium to anodic oxidation, leading to the enhanced formation of hydroxide coverage at the surface and, as a consequence, leading to apparent better corrosion resistance. This is confirmed by the variable energy beam measurements which indicate a thicker oxide layer formation on the surface of the sample SMATed for 120 s.

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