Positron Spectroscopy of Defect Structure of Electron Beam Melted Titanium Ti-6Al-4V Alloy

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Nowadays additive manufacturing (AM) is being actively implemented in aerospace industry. Among the advantages of AM in metals are the possibility of creating unique product shapes, providing solid and lightweight (e.g. lattice) structures in a single manufacturing process and high quality of resulting materials. Additionally, electron beam manufacturing (EBM) technology today provides high rates of production and layer-to-layer component quality control. The use of additive manufacturing also allows creating a new generation of materials with unique set of properties. The same time few issues related to the EBM process in already well established AM materials like Ti and Ti-6Al-4V remain not clear [1-3]. Present paper reports results of the first studies into influence of manufacturing parameters on electron beam melted Ti-6Al-4V alloy defects structure by means of positron spectroscopy.

Positron spectroscopy (PS) methods are the most promising for controlling the small-size defect structure of additive manufacturing materials due to high sensitivity and the ability to determine the type of defects and concentration. Investigation of defects structures carries out by means of positron lifetime spectroscopy (PLS) and Coincidence Doppler broadening spectroscopy (CDBS) on semi-digital complex. The semi-digital complex has excellent technical characteristics using a positron source based on the ^{44}Ti isotope with the activity of 0.91 MBq (the resolution of the digital PLS module is 170 ±7 ps, the energy resolution of the CDBS module is 1.06 ± 0.03 keV.

Positron lifetime spectra of samples with different beam current and speed function were fitted by three exponential components. The first one corresponds to the positron lifetime in the bulk of the material (τ_{Ti} = 147±1 ps). Lifetime values of other two components τ_a and τ_b were referred to the annihilation of positrons trapped by dislocations (τ_{disl} = 165±3 ps) and vacancy complex (τ_{nV} = 291±5 ps) of titanium. The CDBS data also confirm the obtained data.

Depending on additive manufacturing parameters the density of dislocations varies in the range of $10^{13} \div 10^{14}$ m^{-2}, and the concentration of vacancy complexes - $10^{-3} \div 2$ ppm.

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References

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