Materials Science Forum Vol. 607 (2009) pp 108-110
online at http://www.scientific.net

Online available since 2008/Nov/06

Slow Positron Beam Probe for the ZnO/Silicone under Proton Irradiation

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Keyword: ZnO/Silicone; proton irradiation; slow positron beam; effective diffusion length

Abstract: The degradation of ZnO/Silicone coating system under 90keV proton irradiation varying from $5\times10^{14}cm^{-2}$ to $1\times10^{16}cm^{-2}$, was studied by slow positron annihilation spectrum. Effective diffusion length calculated by Variable energy positron fit (VEPFIT) shows a dramatically break in a dose of $1\times10^{15}cm^{-2}$. It is ascribed to the increase of crosslink density and decrease of free volume and hole during the proton irradiation. Furthermore, positron has shown a satisfying sensitivity in detecting the nano-scale defect on ZnO/Silicone system.

1. Introduction

Recently slow positron beam is considered as a unique probe which can be obtained the vacancy distribution directly and non-destructively with a sensitivity of ppm order.

During orbital missions, spacecrafts are exposed in the specific space environment (vacuum, plasma, ionizing radiation, charged particles fluxes, atomic oxygen, etc., which could cripple or disable a spacecraft over a considerable period of time.) Therefore, the development of efficient thermal control system protecting spacecraft's critical subsystems is one of the crucial challenges.

ZnO/Silicone coating is extensively used on spacecraft as a kind of passive thermal control system. The degradation is the primary challenge in utilizing thermal coating, which has attracted much attention. Over decades a great deal of work has been carried out in this field [1,2]. A number of techniques have been used to study the damage defect. In this work, the method of slow positron beam is employed to examine the defect profile under 90keV proton irradiation and the result shows that this technique is a powerful tool in research of coating systems.

2. Materials and methods

ZnO/Silicone samples were obtained by mixing pigment of zinc oxide particles (about 0.4~0.9μm) and binding agents(mainly composed of silicone) and then smearing on stain resistant aluminum alloy substrate up to 20mm in diameter and approximately 150μm in thickness. These samples were irradiated by 90keV proton fluxes with a current of $0.08\mu Acm^{-2}$ at room temperature and the dose ranges from $5\times10^{14}cm^{-2}$ to $1\times10^{16}cm^{-2}$.

ZnO/Silicone coating was investigated by slow positron beam. The energy of the positron beam is variable from 0.25 to 19keV and the annihilation γ-rays was detected using an HPGe Detector (ORTECGEM-10175) with energy resolution of 1.12keV (FWHM) at the 514keV ^{85}Sr γ-ray. Each slow positron spectrum was collected with a total count over 2×10^5 and characterized by the S