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Applied Surface Science 252 (2006) 3327–3332
applied surface science
www.elsevier.com/locate/apsusc

Positron trapping at quantum-dot-like particles on metal surfaces

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Available online 27 October 2005

Abstract

Measurements of the positron annihilation-induced Auger electron (PAES) spectra from the Fe–Cu alloy surfaces with quantum-dot-like Cu nanoparticles embedded in Fe reveal a decrease of the Fe $M_{2,3}VV$ positron annihilation-induced Auger signal intensity and an enhancement of the Cu one for surfaces created by enriching the Cu content of the Fe–Cu alloy. These experimental results are analyzed by performing calculations of positron surface states and annihilation characteristics at the Fe(1 0 0) surface with quantum-dot-like Cu nanoparticles embedded in the top atomic layers of the host substrate. Estimates of the positron binding energy and annihilation characteristics reveal their strong sensitivity to the nanoparticle coverage. Theoretical core annihilation probabilities are compared with experimental ones estimated from the measured Auger peak intensities. The observed behavior of the Fe and Cu PAES signal intensities is explained by theoretical calculations as being due to trapping of positrons in the regions of Cu nanoparticles embedded in the top atomic layers of Fe.

Keywords: Quantum dot; Nanoparticle; Positron; Surface; Auger; Annihilation; Binding

1. Introduction

The physical and chemical properties of quantum dot structures have been the subject of extensive studies because of the prospects of an ever-increasing range of their applications in semiconductor electronics, quantum communications, biological imaging, and cell technology [1,2]. Recently, Nagai et al. [3] have provided clear evidence that positron spectroscopy can be used to characterize the properties of quantum-dot-like nano-particles embedded in host material even at dilute levels as a result of the preferential trapping of positrons in the nano-particles. In this paper, we explore the possibility of using positron annihilation-induced Auger spectroscopy (PAES) [4] to selectively probe quantum-dot-like particles in the top atomic layers of a host substrate. PAES makes use of low energy positrons to create the core ionizations necessary for Auger spectroscopy by annihilation of core electrons. The PAES mechanism

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0169-4332/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.apsusc.2005.08.105