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57Mn Implantation Mössbauer Spectroscopy of α-Al2O3 by Anticoincidence Method

Radioisotope (RI) beam can be applied as a Mössbauer probe to obtain the useful information about site occupations, dynamical behaviors, and exotic chemical states of extremely diluted atoms in ma-terials. In the 57Mn (T1/2=1.45 min) implantation Mössbauer spectroscopy, a gas-filled resonant de-tector with an 57Fe-enriched stainless-steel absorber was used exclusively to obtain Mössbauer spec-tra. The detector, so-called a parallel-plate avalanche counter (PPAC), can collect effectively a few numbers of Mössbauer γ-quanta by accumulating the conversion electrons emitted by Mössbauer effect. However, since 57Mn nuclei decay to 57Fe by emitting high-energy electrons, the β-rays pene-trated to PPAC cause the background level of the spectrum to increase. We improved the detection system to reduce the noise level by using an anticoincidence method between the β−ray and the Mössbauer γ-ray originated from 57Mn, and succeeded to obtain the spectra of a single-crystalline α-Al2O3 with sufficient the S/N ratios. Here, we discuss the final lattice sites and chemical states of 57Fe arising from 57Mn in α-Al2O3 based on the obtained Mössbauer parameters and the results of density functional calculation.

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oral

Summary

57Mn was produced by projectile fragmentation of an 58Fe beam on a Be target using the Heavy Ion Medical Accelerator (HIMAC) of NIRS. 57Mn nuclei (˜106 pps) were implanted into a sin-gle-crystalline α-Al2O3 after passing through energy degraders. A thin plastic scintillation counter was set between PPAC and the α-Al2O3 sample to reject the β-rays that induced high background.

The 57Mn implantation Mössbauer spectra were measured at room temperature (Fig. 1), 193 K, and 92 K. The obtained spectra could be analyzed by three components of doublets from the calculations of ORCA program. It was concluded that D1 (δ =0.43 mm/s, ΔEQ=0.22 mm/s), D2 (δ =0.70 mm/s, ΔEQ =1.31 mm/s), and D3 (δ =0.68 mm/s, ΔEQ =2.43 mm/s) at R.T. were assigned to be substitu-tional Fe atoms on Al sites, interstitial Fe atoms with octahedral symmetry of oxygen, and substitu-tional Fe atoms with an oxygen deficiency. The temperature dependence of these components will be discussed.

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Track Classification: New Directions and Developments in Methodology