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Studies of μ^+ Diffusion and Trapping in dilute Fe Alloys by Longitudinal μ^+ Spin Relaxation Technique

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In the late 1970s and 1980s μ^+spin rotation experiments were performed elaborately to study μ^+ diffusion and trapping in Fe and Fe alloys. In Fe alloys not many experiments were performed, probably because the unavoidable inhomogeneity of the magnetization in ferromagnetic Fe alloys bring about the fast dephasing of spin rotation and may obscure the diffusion and trapping effects. Recently at J-PARC MUSE we have found that the measurement of the longitudinal μ^+spin relaxation time T_L in ferromagnetic Fe alloys is the effective new microscopic technique to study the μ^+ diffusion and trapping in Fe dilute alloys and to investigate how the hydrogen interacts with the principal alloying elements in an attractive or repulsive manner and how the local lattice strain induced by them affect the hydrogen diffusion. We revisit the μ^+SR studies of diffusion and trapping in Fe alloys. We have measured the temperature dependence of the T_L in several dilute Fe alloys containing principal alloying elements such as Ni, Mn, Cr, Ti, Al, Si and interstitial impurities C and O. In some alloys the temperature dependence of $1/T_L$ exhibits the peaks and in some other alloys a hump in a broad temperature region. We have developed the 'two-state' model of ferromagnetic dilute Fe alloys: the trapped state by impurity atom and the freely diffusing state of μ^+. The μ^+SR results are well explained by this model. The peaks are due to the motional narrowing effect where the μ^+-impurity interaction is repulsive and the μ^+ diffuse in the crystal apart from the impurity atoms. The broad hump is due to the trapping and de-trapping of μ^+ by impurities. The 1st principle calculations of hydrogen-impurity interactions, the magnetic moment of the impurity and the local strain induced by the impurity in dilute Fe alloys are compared with the μ^+SR results.

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