Iron-Aluminium Pair Reconfiguration Processes in SiGe Alloys

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The iron-aluminium pair in silicon, among other iron-acceptor pairs, forms the deepest electronic level. This allows observing more distant iron-aluminium pairs which, according to the ionic model of the pair formation, have shallower electronic levels. It has been already well-evidenced that depending on the sample cooling conditions it is possible to convert some of the Fe-Al first-nearest stable pairs (E_V+0.20eV) to the second-nearest Fe-Al pairs characterized by the E_V+0.13eV level. This process is fully reversible depending on the position of the Fermi level during the cooling process. These two pair configurations correspond to different interstitial positions (the first- or second-nearest to the substitutional aluminium) of iron in the crystal unit cell. As a result, the conversion process is a single iron jump between two neighbouring interstitial sites. In this study we have analysed how the alloying affects the electronic levels of the pair in both configurations and to what extent the presence of germanium atoms in the crystals matrix affects the dynamics of the single iron jump process. These studies have been performed in the Czochralski-grown unstrained aluminium-doped $Si_{1-x}Ge_x$ crystals ($0<x<0.032$). Local environments of the Fe_i-Al_s pairs have been observed as structures seen in the high-resolution Laplace DLTS spectra.

In the SiGe alloys the Laplace DLTS spectra for both pair configurations show a structure which we associate with the alloying effect. The main and subsidiary peak separation on the energy scale is similar for both pair configurations indicating that the alloy effect for iron is similar for its both interstitial positions. The amplitudes of the subsidiary peaks are much higher than one would expect if the iron-aluminium pairs in SiGe are formed without any local alloy preference. This iron affinity towards more germanium-rich environment is much more clearly seen for the stable (the first-nearest) pair configuration than for the metastable one (the second-nearest).