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Mössbauer spectroscopic study of the kinetics of sigma-phase formation in cold-rolled Fe-V alloys

The bcc-Fe-V alloy system is not stable for a wide range of compositions around 50%, and upon annealing, the alpha-phase transforms, either into the sigma-phase, or into the ordered metastable B2-phase, depending on the annealing temperature. The B2 is claimed to be a precursor of the sigma-phase. In this study we were interested in the effect of temperature on the alpha-to-sigma phase transformation in plastically deformed Fe-V samples. Ingots of an equiatomic Fe-V alloy were cold-rolled down to form platelets of ˜200 um thickness, which were next isothermally annealed at temperatures between 600oC and 800oC for different periods. Samples prepared in that way were investigated at room temperature by X-ray diffraction and Mössbauer Spectroscopy. The former gave direct evidence on the existence of the sigma-phase, and indirect on the formation of the B2 superstructure via a decrease of the lattice parameter. Mössbauer spectra, that dramatically changed their shape on annealing, gave thereby evidence that the hyperfine field has significantlylly decreased, which is an indication of the formation of the B2 superstructure. Assuming that the shape of the sub-spectrum corresponding to the B2 superstructure does not depend on the annealing time, the kinetics of the sigma-phase formation was followed by studying a temperature dependence of the average hyperfine field.
The results obtained with this procedure are discussed in terms of the Avrami-Johnson-Mehl equation, which yielded kinetics parameters such as the Avrami exponent, n, and the time constant, k. The values of the former are related to the mechanism responsible for the transformation, while the activation energy of the sigma-phase formation was determined from the time constant, assuming the Arrhenius law.

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