Abstract

To observe Moessbauer absorption in ^{57}Fe at high temperatures in transmission arrangement a furnace with a tungsten heating element was conceived. The furnace could be used within a temperature range from room temperature up to 1950°C with an accuracy of +/- 1°C over a period of several days. The absorber temperature inside the furnace was measured with a type C (ENGELHARDT) thermocouple and regulated with a continuously operating temperature regulater with a precision of +/- 1°C. When metallic aborbers were used a temperature gradient of nearly zero was assumed. Due to the design of the furnace, most of all measurements were taken in a near vacuum with pressure in a range of about 10^{-6} mbar. The samples´ diameter did not exceed 15.5 mm. To avoid a decrease of the γ-radiation intensity, beryllium furnace windows and measuring cells made of sapphire, molybdenum and HIP-boronnitride were applied. On account of the high measuring temperatures the apparatus was equipped with an extensive safety system, capable of initiating an emergency shutdown in case of deviation from the supervised parameters.

Using the furnace as described high temperature Moessbauer-spectroscopic investigations in ^{57}Fe in metallic iron with a natural ^{57}Fe concentration of 2.17 % between room temperature and 1400°C were performed. Thus, the ferromagnetic CURIE temperature, the α-γ phase transition and the range up to the γ-δ phase transition at 1398°C could be determined. From the temperature dependence of the total isomeric shift, showing a linear slope of $-7.23 \cdot 10^{-4}$ mm $s^{-1}°C^{-1}$, the DEBYE temperature between 25°C and 930°C was obtained as $\theta_D = 428$ +/-9 K. Between 932°C and 934°C in the total isomeric shift a discontinuity of -0.036 mm/s occurred. The half width between 929°C and 933°C also shows a discontinuity of 0.046 mm/s.

The ferromagnetic CURIE temperature was received by measurement of the temperature dependence of the hyperfine field as $T_C = 1044.6$ +/- 0.5 K. The universal critical exponent was obtained as $\beta = 0.37$ +/- 0.02 and the correction amplitude A = -0.42 +/- 0.09. The total angular momentum was determined with $J \approx 2/2$.

^{57}Fe was electrolytically deposed on molybdenum foils. Over 24 h, the foils were annealed at 1000°C and then cooled over 2 h down to room temperature. Thus, an iron-molybdenum alloy with a content of 10 at-% ^{57}Fe was obtained. The Moessbauer spectrum shows two single lines at room temperature. A single line with a total isomeric shift of 0.037 mm/s belongs to the iron-molybdenum mixed crystal alloy and the other one with a shift of -0.252 mm/s belongs to the intermetallic compound Fe_3Mo_2. The slopes of the temperature dependent total isomeric shifts between room temperature and 1350°C amount for the mixed crystal alloy to $-8.21 \cdot 10^{-4}$ mm $s^{-1}°C^{-1}$ and for the intermetallic compound to $-8.85 \cdot 10^{-4}$ mm $s^{-1}°C^{-1}$. Above 1350°C, the total isomeric shift was found virtually independent from temperature.