

RATE OF HYDROGEN ABSORPTION BY SCANDIUM AT HIGH TEMPERATURE

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Introduction

The mobility of hydrogen in hcp rare-earth metals has been extensively investigated over the past years [1-5]. The main reasons of interest on these materials have been: a) the high solubility of H in their α -phase, even at low temperature, b) the H-H pairing and c) the occurrence of various H-jump regimes. At liquid helium temperature great attention has also been paid to tunnelling effects in diffusion. In the high temperature region ($T < 700$ K) anomalous behaviours have been reported for the nuclear spin-lattice relaxation rate in the dihydride as well as in the solid-solution phase of the IIIB transition metals Sc, Y and Lu. The physical origins of these high temperature anomalies are still unclear. Thus, in order to contribute to a better understanding of these anomalies the rate of H absorption has been measured by the gas-solid surface reaction technique in α -Sc.

Results and Discussion

Several isothermal absorption curves have been traced at various temperatures and pressures of the H_2 gas. A typical absorption curve is shown in fig.1, where the continuous line represent a fit to the experimental data points of the function:

$$p(t) = (p_i - p_f) \exp(-t/\tau) + p_f$$

Here p_i and p_f are the initial and final pressure values and τ the time constant of the process.

The temperature dependence of τ is found to fulfil an Arrhenius type of law over the entire explored temperature range (788K-1250K) as seen in fig. 2. The activation energy W of the associated absorption process turned out to be 1.18 ± 0.08 eV. This value is remarkably higher than the one expected from a comparison with data available for H diffusion in Lu (0.574 ± 0.015 eV [1]) and Y available for H long-range diffusion in α -Lu ($W = 0.574 \pm 0.015$ eV [1]) and α -Y ($W = 0.60 \pm 0.03$ eV [4]).

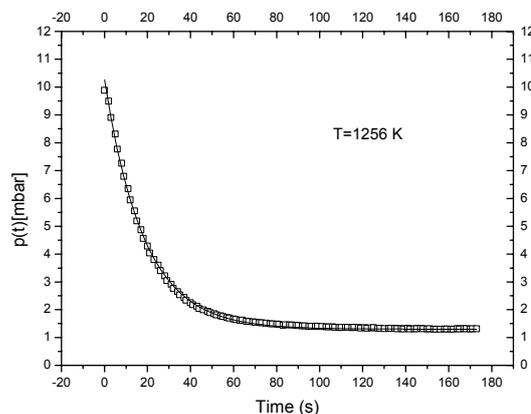


Fig.1. Pressure change during an absorption process and associated fitting curve

On the contrary, it is close to the value reported for a near stoichiometric $ScH_{1.9}$ hydride above 830K [2].

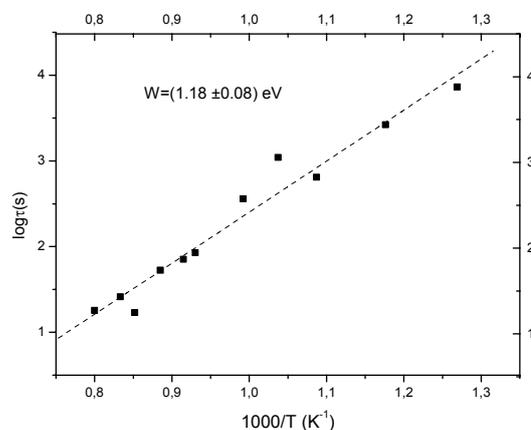


Fig. 2. Temperature dependence of the characteristic absorption time.

This means that the H absorption rate is controlled by the formation of a surface dihydride rather than by H diffusion within the bulk of the material. This is due to the fact that the limit equilibrium pressures for H in solid solution are appreciably smaller (≤ 10 mbar [7]) than the ones used in the present work, which ranged from 10 to 60 mbar.

Conclusions

The present work shows that to deduce the H diffusion coefficient in α -Sc from absorption experiments, low enough pressures of the H₂ gas are required.

References

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