INFLUENCE OF HYDROGEN ON INELASTICITY-ELASTICITY PROPERTIES OF Ti_3Al ALLOY AND SiO_2

Onanko A.P.*, Lyashenko O.V., Onanko Yu.A.
Taras Shevchenko Kiev national research university, physics department,
pr. Glushkova, 2/1, Kiev, 03680, Ukraine,
E-mail: onanko@univ.kiev.ua

Introduction

In the present work the results of examinations of the relaxation processes in a crystalline lattice at H, thermal and ultrasonic processing on the temperature spectrum of internal friction (IF) Q^{-1} and elastic module E (indicatory surface of inelasticity-elasticity body) Ti_3Al alloy are presented.

For measuring of the temperature dependences of IF and elastic module E have been used the methods of fourcomposite piezoelectric oscillator on frequency $f \approx 117$ kHz and resonance vibrations on frequency $f \approx 1{,}4$ kHz during alternative deformation $\varepsilon \approx 10^{-6}$ in vacuum $P \approx 10^{-3}$ Pa.

Results and discussion

On Fig.1 temperature dependence of elasticity module E and IF Q^{-1} (indicatory surface of inelasticity-elasticity body) Ti_3Al alloy is presented after mechanical treatment and hydrogen H during $t \approx 7200$ sec.

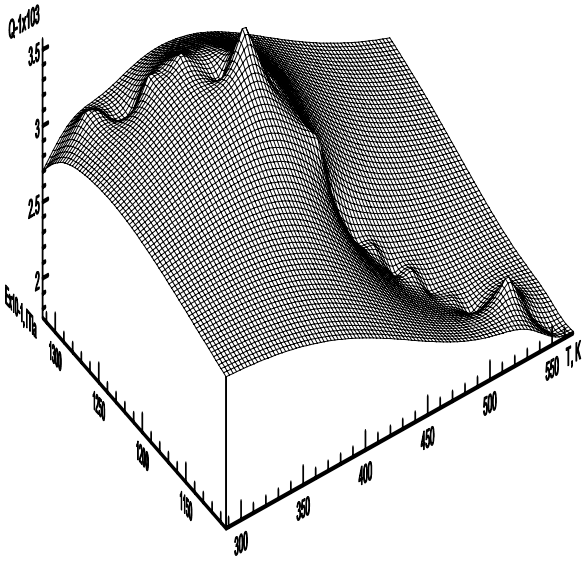

Fig.1. Temperature dependence of elasticity module E and internal friction Q^{-1} (indicatory surface of inelasticity-elasticity body) Ti_3Al alloy after mechanical treatment and hydrogen H during $t \approx 7200$ sec.

There was observed the maximum of IF Q^{-1}_{M1} in Ti_3Al at temperature $T_{M1} \approx 390$ K with activation energy $H_1 = 0{,}77 \pm 0{,}1$ eV, time relaxation constant of this maximum IF $\tau_{01} \approx 1{,}9 \cdot 10^{-14}$ sec, relaxation frequency factor $f_{01} \approx 5{,}3 \cdot 10^{13}$ Hz, conditioned by the relaxation mechanism caused by reorientation interstitial atoms of H-H in dumbbell configurations at the ultrasonic alternative deformation ε.

On Fig.2 temperature dependence of elasticity module E and IF Q^{-1} Ti_3Al alloy is presented after hydrogen H during $t \approx 14400$ sec.

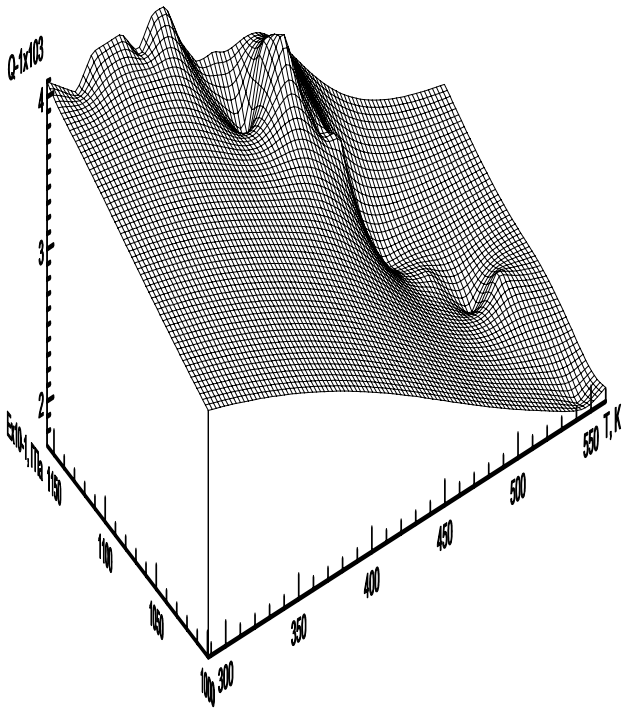

Fig.2. Temperature dependence of elasticity module E and internal friction Q^{-1} (indicatory surface of inelasticity-elasticity body) Ti_3Al alloy after hydrogen H during $t \approx 14400$ sec.

The IF maximum Q^{-1}_{M2} in Ti_3Al alloy at the temperature $T_{M2} \approx 440$ K was discovered with the value of activation energy $H_2 = 0{,}85 \pm 0{,}1$ eV, time relaxation constant $\tau_{02} \approx 1{,}8 \cdot 10^{-14}$ sec, relaxation frequency factor $f_{02} \approx 5{,}5 \cdot 10^{13}$ Hz. To this IF maximum Q^{-1}_{M2} possibly conditioned the process of running the number of vacancies V in vacancy complexes under act of alternative deformation ε.

The IF maximum Q^{-1}_{M3} in Ti_3Al alloy at the temperature $T_{M3} \approx 530$ K was discovered with the value of activation energy $H_3 = 1{,}0 \pm 0{,}1$ eV, time

relaxation constant $\tau_{03} \approx 3{,}1 \cdot 10^{-14}$ sec, relaxation frequency factor $f_{03} \approx 3{,}2 \cdot 10^{13}$ Hz.

There was a high initial size of IF background $Q^{-1}_0 \approx 8{,}0 \times 10^{-3}$. Considerable high initial IF background Q^{-1}_0 at the first heating comparing to the IF background Q^{-1}_0 at the repeated heating testifies to the presence of the fields of stress σ_i in the Ti_3Al alloy, which arise up as a result of mechanical treatment. Anomalous motion of IF background on Fig.1 and Fig.2 testifies to diminishing of values of these tensions σ_i in the process of heating. Annealing of structural defects bends out of shape the type of IF temperature spectrum. At annealing admixtures, vacancies moves.

For IF maximum Q^{-1}_M the condition of its existence is written down in a kind [1]:

$$\omega_M \tau_0 \cdot \exp(H/k_B T_M) = 1. \qquad (1)$$

From the resulted correlation (1) swims out, that $H = k_B T_M \cdot \ln(1/f_M \tau_0)$. Putting $\tau_0 = 1/f_0 = h/k_B T_M$, get a formula for determination of activation energy H of IF maximum

$$H = k_B T_M \cdot \ln(k_B T_M / h f_M) + \Delta S, \qquad (2)$$

where $T_м$ and $f_м$ is a temperature and frequency of IF maximum Q^{-1}_M accordingly. Entropy addition ΔS lies within the limits of experimental error; exactness of estimation of H depends mainly on exactness of support of specimen temperature (2 K) ≈ (2%). Use for determination of H the temperature position T_M of IF maximum and frequency of specimen vibrations fм does not require implementation of the special terms. At imposition of relaxation processes the temperature position of T_M of every IF maximum Q^{-1}_M is easily measured, and frequency $f_м$ is set experimentally.

The elastic module E is more sensible description of processes of physical interaction at boundaries of section, than IF. The elastic module E has descending linear character which is explained the theory of unharmonicity of crystals taking into account quadratic members [1]. Diminishing of the elastic module E was not related to the hysteresis dislocation process, so as IF was amplitude independent. On elastic module Ti_3Al alloy temperature dependence E(T) there was the relaxation of the elastic module $\Delta E/E$ in the area of existence of IF maximum $T_{M1} \approx 390$ K. There was the increasing of absolute value of the elastic module E after annealing, that testified the strengthening of alloy.

By reason of induced hydrogen H no communicative plasticity is an enhance concentration of conductivity electrons e – metallic character of atoms connections is increased hydrogen. The local increasing of concentration of conductivity electrons e in hydrogen clouds round the dislocations results in diminishing the shear module G and the tension of activating of dislocations sources σ_D [2]. H strengthens metallic character of atoms connections, which can not be reason of fragile destruction. Diminishing of distance between dislocations L_D in accumulations due to hydrogen H results in the increase of dislocations in its and to the increase of tension on leading dislocation σ_D, that is reason of the facilitated microcrack.

Conclusions

The relaxation of elastic module $\Delta E/E$, looked in the same temperature interval of existence of IF maximums Q^{-1}_M testified to the relaxation process, linked with the reorientation of the vacancy - hydrogen V-H complexes under the ultrasonic variable deformation ε.

References

1. Novik A., Berri B. Relaxation phenomena in crystals.– M.: Atomizdat, 1975.– 472 p.
2. Kolachev B.A. Physical metallurgy of titan.– M.: Metalurgiya, 1976.– 276 p.