THERMAL-RADIATION PROCESSES (LINK 2)

For the first time, the systematic study of thermal-radiation (TRP) processes in Me-H, Me-N-H, Me-C-H, Me-Me`-H, etc. systems were carried out. The main goal of the research was to determine the influence of accelerated electrons' beam on the interaction of hydrogen with metals. Earlier, TRP in the metal-hydrogen system was not studied. The research was conducted jointly with the Yerevan Physics Institute on the linear accelerator of electrons LAE-5. As a result, thermal-radiation synthesis (TRS) of hydrides of transition metals and alloys was realized for the first time. More than 50 different binary and complex hydrides were produced. Among them: TiH_2 and $ZrH_2$of stoichiometric compositions, $HfH_{2.2\text{-}2.4}$ super-stoichiometric (H/Me>2) hafnium hydride (crystal lattice parameters a=4.911, c=4.405), carbohydrides and hydrides of titanium, zirconium, intermetalics, etc. Actually, one more, fundamentally new direction in the field of synthesis of hydrides of transition metals, Thermal-Radiation Synthesis (TRS) was developed. The temperature profiles of TRP in the studied systems allowed describing several important regularities and the mechanism of hydride formation in the beam of accelerated electrons. Figure 1 shows the TRP thermograms at irradiation of Ti in hydrogen and argon. From these temperature profiles it is seen that at the beginning of the process, with the increasing of radiation dose up to 20-30 Mrad, the temperature smoothly increases to 200-400°C mainly due to irradiation heating. This heating is sufficient to initiate $Me+H_2$ exothermic reaction in the whole volume of the sample. At the same time, the temperature of the process increases sharply to 695°C for Ti and 760°C for Zi. Actually, under the beam of accelerated electrons, a thermal explosion occurs in the whole volume of the sample (Fig. 1, curve 1). Curves 3 and 4 show the temperature profiles of heating of hydrogenated sample in argon and in hydrogen, respectively.

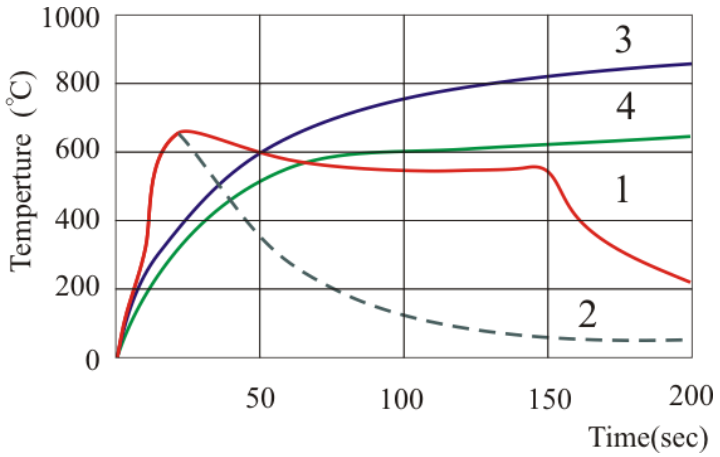

Fig. 1. TRP thermogram at irradiation of Ti in hydrogen environment (0.7 Mrad/sec).

We can say that the TRS and SHS processes are similar in many respects. Both processes are easily initiated, fleeting and proceed due to a self-sustaining exothermic reaction. The final result of both processes is the synthesis of hydride of the corresponding metal. The mechanism of hydride formation in TRS mode, similar to that in SHS, is two-stage. The only difference is that in SHS the zone of exothermic reaction propagates frontally, but in TRS the reaction occurs in the whole volume of the sample at once, similar to the thermal explosion.

The effect of preliminary irradiation in vacuum on the metal, for example hafnium, was studied (Fig. 3, blue curve). It shows that when the electron beam is turned off and the sample is cooled, in a few seconds after hydrogen filling into the chamber, the thermocouple registered a sharp jump of temperature to 650^{o}C (Fig. 2, red curve). This jump indicates the exothermic reaction of the sample interaction with hydrogen. As a result, the hydride of corresponding metal formed. The further course of the reaction was analogous to TRS. This reaction was called "cold synthesis" (CS). Based on the data of the above-described experiment, one can explain the CS phenomenon as a consequence of exclusive effect of radiation on the crystal lattice.

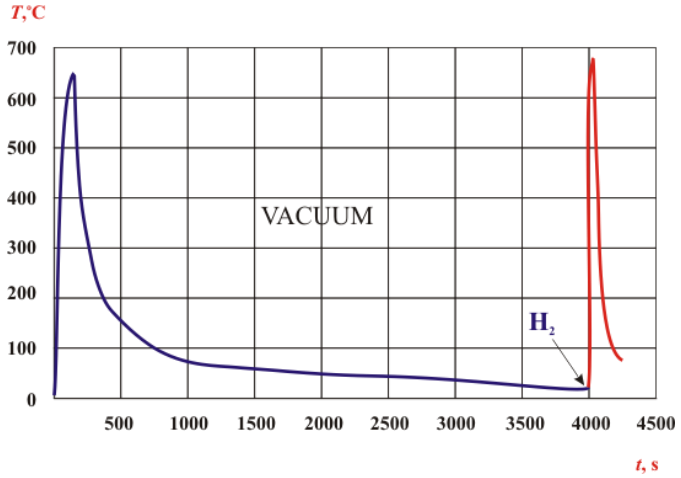

Fig.2. Thermogram of “Cold Synthesis” of titanium hydride

LIST OF MAIN PUBLICATIONS

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Date	Project Title	Principal Investigators
2003	**ISTC #A-575** "Synthesis and investigation of hydrogen containing materials used in biological protection from ionizing radiation" , Status 3 "Approved without funding"	S.K.Dolukhanyan
1998-2001	**ISTC A-192 -** Electron Beams for Hydride Formation, "The Influence of Electrons Beams on Formation of Binary and Multicomponent Hydrides with Extremal Properties"	S.K.Dolukhanyan