Nuclear Physics Approach

THE NUCLEAR REACTIONS IN CONDENSED MEDIA FOR INTERACTION OF CHARGE PARTICLES IN ENERGY REGION IS FORMING BY MAXIMUM ELASTIC LOSSES

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Abstract

The main requirements to reproduce the generation of nuclear reactions in condensed media (NRCM), have been identified which appear to influence the interaction of fast hydrogen ions with a solid target in a powerful plasma glow discharge. Phenomena of three branches of physics have contributed to this work: nuclear physics, solid-state physics and low-energy plasma physics, and have in turn opened a new direction of fundamental research. The essence of this new direction is the ability of a low-enrgy plasma to interact with a solid target, creating nuclear reactions at a rate several orders of magnitude than predicted by calculations for the some conditions.

The experimental results are presented, which validation the formation of a new direction for nuclear research.

1. Introduction

Earlier work [1-3] had shown, that by using particular conditions to stimulate NRCM at low energies of interacting particles, excess energy can be created. These reactions arise at bombardment of a solid specimens by accelerated of a hydrogen isotops, besides the quantity of generated energy can be registered on such products of the nuclear reactions, as for example, tritium . The set of experimental results is already sufficient as for formation of scientific problems, as main directions of use NRCM.

The present work is devoted to formulating this new fild of nuclear phenomena and assessing the prospects of their practical use power systems.

2. Equipment and Methodology

Experiments to study excess heat, production of transmutation elements and generation of neutrons and tritium, helium-3 and helium-4, charged particles, and gamma and x-ray radiation we carried out primarily by using a dc glow discharge in the upgraded installation UVN-84R-1 [4].

The 250-l vacuum chamber included a heater for outgasing the chamber. The discharge unit consisted of a sample-cathode, anode, ceramic insulators and thermocouples. The vacuum system consisted of two turbo-molecular pumps TMN-200 and TMN-500, trap by nitrogen, a mechanical pump and control valves. The plasma-forming gas was filled into the chamber through a system of filtering and control valves. The pressure was controlled by thermo-coupling, ionization, mechanical and oil pressure gauges in a range from 10^{-5} Pa up to 10^{5} Pa.

The essence of our experiments [4-7] consisted that ions of hydrogen isotops was bombarded the sample-cathode of plasma glow discharge at submission of negative potential on a sample. For sample used plates, tubes with thickness of walls of 0.2-5 mm and rods by a diameter of 2-20 mm. Samples were make from diverse metals, predominary from hydride-formation and refractory. The basis of a plasma-formation gas was deuterium with the contents protium in atomic fractions up to 5 % and tritium up to $(6-8)\cdot10^{-10}$ %, pressure of which supported in limits ($1-1.5\cdot10^{-3}$) Pa.

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The energy of ions, depending on pressure, was evaluated within the limits of Ø.7-Ø.Ø1 from voltage of the glow discharge, which changed from 2ØØ V up to 1ØØØØ V. The current density made $5.1Ø^{-6}$ - $1Ø^{-5}$ A/m^2. The sample temperature during researches set of 7ØØ K to 36ØØ K.

Registration of slow neutrons executed by a system RTN from 6Ø gauges SNM-12 on the basis helium-3. The registration of fast neutrons was executed in addition by a shielded device RUP-1 with scintillator on the basis of a zinc sulphide activated by silver. The sensitivity of measurement a flow of neutrons reached 1 neutron/s, and the error was limits within of the order from measured magnitude.

Analysis of the deuterium on tritium, assembled before and after ions bombardment, conducted on beta-activity by a liquid scintillation method on the equipment Beta-2. The error of measurement of the contents tritium in tests made 1Ø-5Ø %.

3. Main Results

Researches on measurement of a flow neutrons, conducted at bombardment of various elements by accelerated deuterium ions from a plasma of glow discharge with energy up to 1Ø keV have shown, that the excess of a background level on fast neutrons reaches not more double excess even for a tritium-titanium target [4].

The most significant results are received by us at registration NRCM on a tritium generation. The initial level tritium in deuterium, measured on beta-activity, is exceeded on four-five orders, and the tritium generation rate reached $1Ø^{7}$ Atom/s for glow discharge and $1Ø^{11}$ Atom/s for a device on the basis Z-pinch. Thus the coefficient of nuclear interaction has made about $1Ø^{-19}$ Atom/ion.

Measurements of tritium in a gas confirmed by duplication of measurements on flowing beta-recorder from a surface sample, at simultaneous registration of a spectrum energy, radiography of a surface at the help x-ray films as well as control of the tritium contents in the material sample.

It is fixed ittrium transmutation in zirconium on high-energy beta-activity of radiated samples, with zirconium-to-tritium flux ratio at the level $1Ø^{4}$ - $1Ø^{6}$. The main experimental results, which permit to declare formation of a new direction of nuclear researches, can be grouped in the following order:

1. The rate NRCM in the energy range of ions 1Ø - 1ØØØØ eV, determined on the tritium generation rate, exceeded of the calculation for thermonuclear channel on a some orders.

2. The neutron-to-tritium branch ratio on generation rate measured by us reached $1Ø^{-4}$ - $1Ø^{-7}$, which while it is impossible to consider final of, in comparison, small flows of neutrons [4]. These results will be well agreeed other researches, for example, with [8]. Usually, at high-energy interaction, this ratio is close unit.

3. The speed of nuclear reactions depends on the nuclear number of a target material and concentration of a hydrogen in the material. According to experimental results, the rate NRCM was increased with increasing concentration of the hydrogen and increasing nuclear number of the target material and maximum results, up to present time, are received on zirconium, niobium and tungsten [2,4]. However, for heavy materials, located higher of the middle Mendeleev table, unequivocal results to receive has not managed. While it is not known, whether it is connected with unsufficient optimization regimes of ion bombardment or with new law.

4. Dependence of efficiency NRCM from energy of ions is present by self threshold dependence (about 1ØØ eV) and is weak varying at energy higher threshold.

5. For processes NRCM the dependence of a tritium generation efficiency from current density is close to linear [1]. It give a opportunity to select parameters of ion bombardment for maintenance of necessary speed of nuclear reactions.

6. The dependence of efficiency tritium generation from pressure of the plasma-forming gas has maximum in the range 100000-300000 Pa and has no analogues in usual processes [5].

The submitted dependences are received in a plenty of experiments, the general number of which exceeds thousand, that makes results statistically determined and conclusion-safety.

4. Discussion

At use bombardment by accelerated ions for targets of containing hydrogen , for stimulation of nuclear reactions in condensed media, maximal specific excitation for loading hydrogen is reached at maximal relation for elastic and unelastic losses of energy by ions, driving in given media. This energy depends on the masses of interacting particles and for hydrogen is on level of several tens eV [4]. This energy already enough for creation radiations, structural damage of materials [9]. Thus, intensive ion bombardment can render the influence as on characteristic of interaction protons of solid in surface layer (the nonactivation interaction on length of free run and for reason of diffusion parameters change in process radiation), as in volume of solid at increased temperatures (for reason change of static and dynamic parameters on structure of material, affecting diffusion and solubility). At temperatures above 0.3 $T_{пл}$ the moving of dot defects and defects of dislocation type from surface layer of metal deep into, on distances, considerably the exceeding zones of free run of ions (some of orders) [9] is observed as diffusion. The study of this question has shown, that the intensity of change of structure is possible to be evaluated on "effective coefficient of dislocation diffusion". We made assumed, that effective coeffitient diffusion dislocation it is present the multiplication of self-diffusion coefficient under condition thermo-activation and self-diffusion coefficient under condition ion bombardment : $D_{эфф} = D_{изл.} \cdot D_{изл.}$. We used dependence $f(x) = kx/(a + x)$ for approximation of the experimental datas and for getting the self-diffusion coefficient under condition of ion bombardment $D_{изл}$ on known $D_{эфф}$ and $D_{терм}$. The coefficients a and k was got out experimental datas by the method of lesser squares:

$$D_{efd} = 0.28e^{\left(\frac{386020}{RT}\right)} \cdot e^{\frac{[E_t \cdot 0.25\sqrt{\rho(\varepsilon)} \cdot \sqrt{M_1/M_2}]/(0.2+\sqrt{\rho(\varepsilon)}) \cdot (0.2+\sqrt{M_1/M_2})}{KT}}$$

Were: R-gase constant; k-constant of Bolzman; T-temperature; E_t-threshold energy for displacement of atomtarget; r(e)-specific projection run of ion in target material; M_1-ion masse; M_2-atom masse of target.

The calculation accurasy by this formula for energy (10 - 1000 eV) and temperature (0.3 - 0.7) $T_{пл}$ it is estimate in one order of value (Fig. 1). From drawing it is visible, that the change of structure happens much slower of hydrogen diffusion. So for molybdenum, at temperature 1900 K effective coefficient diffusion for protium has made about $4 \cdot 10^{-7}$ $m^2 \cdot s^{-1}$, and coefficient diffusion for dislocations made about 10^{-12} - 10^{-11} $m^2 \cdot s^{-1}$ at energy of ions, order 500 eV and density of current 300 A/m^2. It is thus possible to conclude, that the stimulating action of ion bombardment on efficiency NRCM flowing can consist in increase for quantity of protons collisions and deuterons in surface layer and in increase of hydrogen concentration in volume as for reason of surface barriers, as for reason structures radiation damage and formations new one.

5. Use Direction Of NRCM

- Power engineering.

The new class offered to use of reactions will allow to expand scientific base of a nuclear power and to create the new areas for its application. On the basis of use for offered reactions it is probably to develop technological pro-

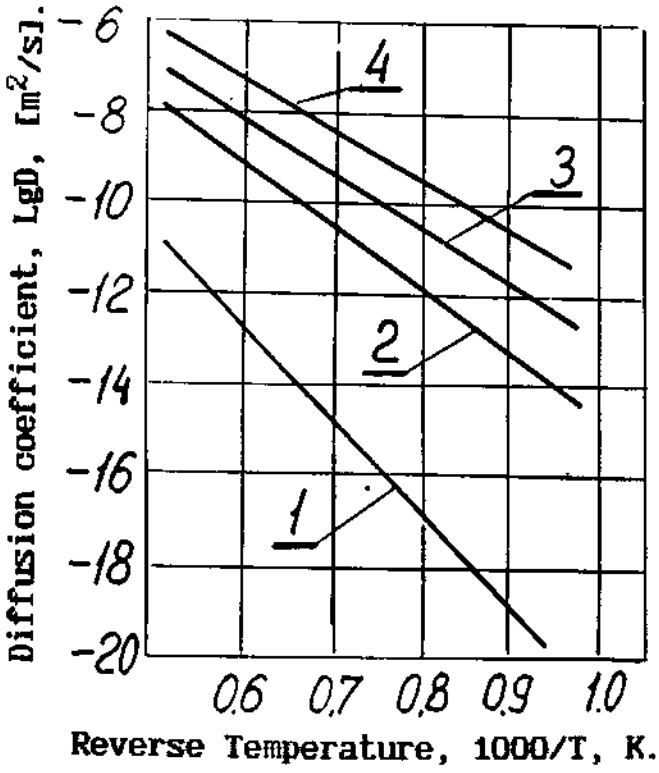

Fig. 1. The dependence of coefficient diffusion for dislocation versus reverse temperature. 1-Energy ions- 0 eV; 2- 40 eV; 3- 400 eV; 4- 40000 eV.

cesses of manufacturing stationary, mobile and transport power installations with increased ecological.

-Storage and processing wastes.

The increase of ecological safety to bury of a fulfilled nuclear fuel is possible at revealing of a acceptable way to transfer of long time living nucleuses a radio-active elements, for example, Pu in a few time living isotops. Ofered use of directed reactions in condensed media for processing a wastes is based on experimental results and theoretical reasons, that the speed of specified reactions for heavy elements can be whole on two and four order less in comparison with speed for easy.

- Rare isotops generation.

As the most perspective direction transmutation at the expense of nuclear reactions in condensed media at low energy of interacting particles it is possible to consider a operating time of astable easy elements for a science, manufacture and medicine, for example, to the tritium generation for termonuclear reactors.

-Isotops sources of a light and energy.

The low cost of generation for low energy isotops in offered nuclear reactions makes it is possible development of diverse technologies for use isotops in independent sources of the light and energy.

6. Conclusion

6.1. The submitted complex of experimental results testifies that a new direction of nuclear researches as on a range used energy, as on features flowing of reactions and structure of products which generated.

6.2. It is shown, that safety of received results is reasonably high, as far as they are received in a plenty of experiments by poweful glow discharge for high temperature and structure modification, statistically are determined .

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6.3. It is marked, that the main directions of use NRCM in a power engineering, rare isotops generation and processing waste are expand a sphere of application to conventional sources of nuclear energy and improve its the economic and ecological characteristics.

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