DEVELOPMENT OF A PULSED BREMSSTRAHLUNG SOURCE ON A BASE OF A NANOSECOND AND MICROSECOND REB ACCELERATORS

A.B.Batrakov, A.M.Egorov, N.I.Gaponenko, E.G.Glushko, Yu.F.Lonin, N.I.Rudnev, B.V.Sereda, I.M.Neklyudov, A.A.Parkhomenko, A.G.Grivo, A.V.Mazilov
NSC KIPT, Kharkov, Ukraine

In the paper the preliminary results on measuring parameters of a pulsed bremsstrahlung source developed for investigation of physical-mechanical properties of reactor materials are given. Generation of **γ**-radiation with parameters γ ~ 0.4...1.0 MeV was carried out at microsecond and nanosecond high-current REB accelerators. The absolute values of an absorbed dose are determined for both nanosecond and microsecond sources of γ-radiation.

PACS: 29.25.Bx, 41.60.-m

1. INTRODUCTION

At present in the USA, Europe, Japan and Russia [1] major attention is given to works on developing and introducing the beam-plasma methods for modification of surface properties of materials. The important circumstance is also that in a series of cases the plasma-beam treatment allows to obtain such structure-phase states of materials which can not be realized by traditional methods.

The modification of surface properties of materials by means of powerful pulsed electron beams is one of quickly developing and effective methods. When a material is under action of such a beam, its layer (of an order of particle path in this material) can be heated very quickly to temperatures of phase transitions. The heating and cooling rates depend on properties of a material and beam parameters - the heating rate can reach $10^8...10^{11}$ degrees/s and the cooling rate reaches $10^7...10^9$ degrees/s. All this is realized in a so-called adiabatic mode of irradiation when the energy carried by the beam into the material remains within the limits of a surface layer during all the period of beam duration, i.e. it does not propagates deep into the material at the expense of a thermal conduction. After the beam pulse duration is finished there is a quick cooling of the treated layer due to the heat conducting deep into the material.

2. EXPERIMENTAL PART

In the source under development one uses a principle of obtaining an intense radiation of γ-quanta under irradiation with a pulsed electron beam of converters made from materials with a large atomic number. For this purpose the accelerator “Start” is involved [2], in the diode of which the electron beam is formed with the following parameters: electron energy **E**=0.7...1.0 MeV, beam current **I**=10 kA, current pulse duration (on half-width) **t**=10 ns. In these experiments the geometry and the beam parameters were chosen so that they should correspond to sizes of detectors and be generate the maximum γ-radiation value. The scheme of the experiment at the “START” is shown in Fig.1. Measuring of beam current duration was performed using the Rogovsky belt, and Y-radiation was measured by means of the pin-detector.

The oscillograms of a current and γ - radiation are given in fig.2.

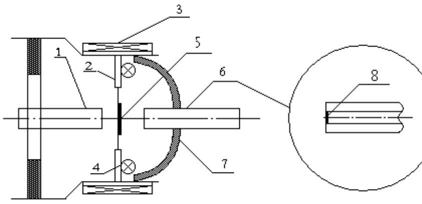

Fig.1. Scheme of the experiment at the accelerator “START”: 1-cathode, 2-anode, 3-magnetic field, 4-Rogovsky belt, 5-converter, 6-channel of X-ray diagnostics, 7-insulator, 8-detector of γ - radiation

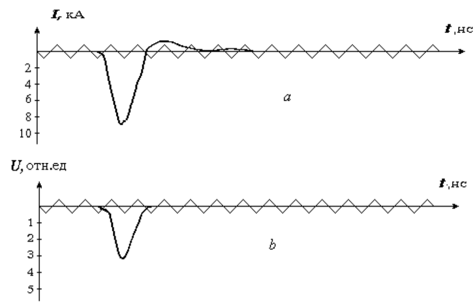

Fig.2. Oscillograms of the beam current (a) and γ - radiation (b)

It should be noted that the current duration measured by the Rogovsky belt (fig.2,a) coincides with the radiation duration measured by the pin-detector (fig.2,b). The electron beam density is given by a system of beam formation and can be in limits 0.1...1.0 MA/cm^2 [3].

The γ-radiation was generated due to the beam deceleration at the converter made of refractory materials (W, Ta) and installed on the anode of the diode of the accelerator instead of the grid. The maximum depth of 1 MeV electron penetration into tungsten is according to [4]: $\delta = 10^{-5} \cdot E^{3/2}/\rho = 0.17$ mm, where: **ρ** is the specific weight of tungsten (g/cm^3), **E** is the electron energy (keV). Consequently, as a converter, one can use a tungsten foil with a thickness of 0.15...0.2 mm.

The γ-radiation and the absorbed dose were measured with the use of a pin-diode and a LiF absorber arranged at different distances from the converter. The absorber was a polycrystalline LiF pellet (d=3.5 mm, h=2 mm, S=10 mm^2, ρ=1.17 g/cm^3) activated by Ca, Mg and Ti. The absolute values of the absorbed dose were measured with the help of a tested universal thermoluminescent dosimeter DTU-01. The best studied is the mode of the tungsten plate (**б**=0.25 mm) irradiation with an electron beam of a current density equal to **J**=0.2 MA/cm^2 (I_b=10 kA, r_b ≈0.2 cm, S_b ≈13 mm^2). The increase of the current density leads to the burning of the converter that limits the intensity of the γ-radiation bremsstrahlung flux. The burning of the converter, as a rule, takes place at 5-6 pulses, and the size of the burnt hole corresponds to the beam size (see fig.3).

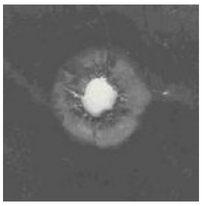

Fig.3

The maximum value of the absorbed dose measured in the channel 6 (fig.1) at a distance 132 mm was ≈ 10^2 Gr. The total dose can be increased by two orders of magnitude by the repeated triggering of the accelerator.

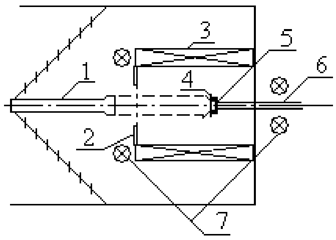

Fig.4. Scheme of the experiment at the "TEMP-B"1-cathode, 2-anode, 3-magnetic field, 4-converter, 5 -detector of γ- radiation, 6-collector, 7- Rogovsky belts

Similar measurements were carried out also on the microsecond REB accelerator "TEMP-B" with the beam parameters: $\mathbf{E}_b$~1 MeV, $\mathbf{I}_b$~25...45 kA, **t**~2.5 μs. The scheme of the experiment at the "TEMP-B" is shown in Fig.4. In these experiments the beam had the following parameters: $\mathbf{E}_b$~0.5...0.6 MeV, $\mathbf{I}_b$ ≈25...30 кA, and duration ~2.5 μs. The cross-section beam area was ~700 mm^2.

The measuring of the γ-radiation and absorbed dose was conducted similarly to the measuring at the "START". As a converter we used Ta (pos.4, fig.4) placed directly on the collector (pos.6), and the LiF detector was installed in the converter space behind the converter. Time characteristics of the γ-radiation were measured by the pin diode placed on the outside of the flange in the collector region. The absorbed dose per one pulse for a LiF pellet was ~400 Gr, and, consequently, the total dose was ~3·10^{4}Gr. The increase of the dose can occur due to the increase of the pulse quantity.

3. CONCLUSIONS

So, it was shown experimentally that on the base of nanosecond and microsecond REB accelerators one can develop the γ-radiation sources with 0.3<$\mathbf{E}_\gamma$ <1.0 MeV and different cross-section areas 12<$\mathbf{S}_\gamma$ <700 mm^2, moreover, the absorbed dose can be varied from 10^2 Gr to several units **10^5 Gr.**

REFERENCES

1. Physics and technique of pulsed sources of ionizing radiations for investigation of fast running processes, Ed. by N.G.Makeev, Sarov, VNIIEF, 1996, p.490 (in Russian).
2. N.I.Gaponenko, Yu.V.Tkach et al. *High-current nanosecond electron accelerator "START":* Preprint KIPT8429, M.,TsNIIatominform, 1984 (in Russian).
3. S.V.Adamenko, V.A.Stratienko et al. /Formation and usage of dense electron beams and secondary radiations. // *Voprosy Atomnoj Nauki i Tekhniki. Series:Yaderno-Fizicheskie Issledovaniya.* 1997, No 4,5 (31, 32), v.2, p.163-165 (in Russian).
4. V.F.Kovalenko. /Calculation of the electron penetration depth // *Ehlektronnaya tekhnika, Series 1. RF Elektronika.* 1972, N1, p.3-11 (in Russian).

СОЗДАНИЕ ИМПУЛЬСНОГО ИСТОЧНИКА ТОРМОЗНОГО ИЗЛУЧЕНИЯ НА БАЗЕ НАНОСЕКУНДНОГО И МИКРОСЕКУНДНОГО УСКОРИТЕЛЕЙ РЭП

А.Б.Батраков, А.М.Егоров, Н.И.Гапоненко, Е.Г.Глушко, Ю.Ф.Лонин, Н.И.Руднев, Б.В.Середа, И.М.Неклюдов, А.А.Пархоменко А.Г.Гриво, А.В.Мазилов

Приведены предварительные результаты по измерениям параметров импульсного источника тормозного излучения, создаваемого для исследования физико-механических свойств материалов реакторостроения. Генерация СЖР излучения с параметрами 0,4< γ<1,0 МэВ осуществлялась на микросекундном и наносекундном сильноточных ускорителях РЭП. Определены абсолютные значения поглощенной дозы, как для наносекундного так и микросекундного источников γ-излучения.

СТВОРЕННЯ ІМПУЛЬСНОГО ДЖЕРЕЛА ГАЛЬМОВАНОГО ВИПРОМІНЮВАННЯ НА БАЗІ НАНОСЕУКНДНОГО ТА МІКРОСЕКУНДНОГО ПРИСКОРЮВАЧІВ РЕП

О.Б.Батраков, О.М.Єгоров, Н.І.Гапоненко, Е.Г.Глушко, Ю.Ф.Лонін, Н.І.Руднєв, Б.В.Середа, І.М.Неклюдов, О.О.Пархоменко, О.Г.Гриво, О.В.Мазілов

Приведено попередні результати по вимірюванню параметрів імпульсного джерела гальмованого випромінювання, якій створюється для дослідження фізико-механічних властивостей матеріалів реакторобудівництва. Генерація НЖР-випромінювання з параметрами 0,4< γ<1,0 МеВ здійснювалась мікросекундному і наносекундному сильнострумових прискорювачах РЕП. Визначені абсолютні значення дози поглинання, як для наносекундного, так і мікросекундного джерел γ-випромінювання.