SMALL-SIZE HIGH-PERFORMANCE ARSA ACCELERATORS FOR ON-LINE TESTING FOR ECB RADIATION HARDNESS

S.L.Elyash, S.P.Pukhov, A.V.Rodigin, A.L.Yuryev, RFNC-VNIIEF, Sarov, Russia

Abstract

At present an extent of electrical engineering item tests for pulsed ionizing radiation (IR) hardness has abruptly increased. Solving of such problems with the help of only powerful simulators seems impossible due to significant time and material costs. Results of studies, performed in RFNC-VNIIEF, RISI and other organizations [1], have shown that optimal combination of small-size high-performance accelerators ARSA and powerful simulators allows a significant reduction of terms and costs for radiation tests, an increase of fidelity and self-descriptiveness of the results obtained.

As opposed to IC test simulation methods using laser radiation, ARSA accelerator employment allows approaching of the process inspection conditions to the real-life environment [2].

BRIEF DESCRIPTION OF ARSA ACCELERATOR

ARSA is a small-size pulsed electron direct-action accelerator with oil insulation [3, 4], see fig. 1. It consists of a high-volt unit 1 with accelerating tube 4, located in the sealed container, charger 2 and a control board 3. A specific feature of a ten-cascade Marx generator used in the accelerator is a pulsed charging of reservoir capacitors. Cascade current is switched with the aid of metal-ceramic pressurerized spark gaps [5].

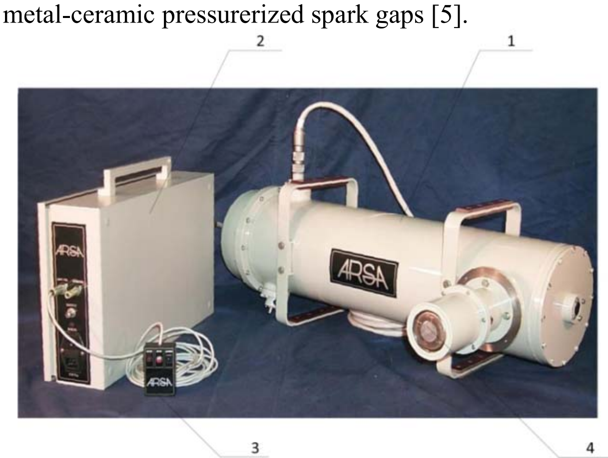

Figure 1: Small-size pulsed accelerator ARSA.

A sealed-off accelerating tube with a through target represents a vacuum diode with an explosive-emission cathode and titanium anode. Anode of 50 μm thickness is an output window for electron beam. To generate bremsstrahlung radiation onto the outer tube window surface there is mounted a target made of 50 μm thick tantalum foil and 2 mm thick aluminum filter for absorption of electrons passed through the window and target. Edge type cathode of diameter 10 mm supplies a homogeneous radiation spot.

A PULSED FIBER-OPTIC MONITOR-DOSIMETER WITH A DETECTOR CHANNEL FOR RADIATION PULSE SHAPE MONITORING

For the purposes of on-line monitoring of small-size pulsed ARSA accelerators' dose a fiber-optic monitor–dosimeter (MD) [6] has been developed, see fig. 2. It is structurally unified and used together with the accelerator's control panel. For MD one foresees also a possibility for autonomous operation in the mode of dose monitoring.

Figure 2: Fiber-optic monitor-dosimeter, combined with ARSA control panel.

MD represents a combination instrument, comprising:

- fiber-optic pulsed X-ray dose meter;
- pulse counter with nonvolatile memory for control over the facility life;
- storage device for each pulse dose values;
- pulse dose adder in a series;
- blocking device upon a specified dose is reached;
- port for reading of accumulated data into the computer.

Fiber-optic pulse dosimeter has a number of advantages:

- instant obtaining of measurement result as compared to the thermoluminescent dosimeter;
- high noise immunity, low detector's degradation as compared to meters based on semiconductor diodes;
- availability of new service-feature features (counter, adder, nonvolatile memory, port), due to employment of modern micro-processor.

A radiation detector in the device is scintillator CsI(Tl). The light is transferred from the detector to a photodetector through plastic fiber-optics of 1 mm diameter. A pin-photodiode is used as a photodetector. A peculiar feature of MD structure is a one-piece assembly

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«scintillator-fiber-optic-photodetector», what increases measurement stability as compared to the multi-piece one.

In order to monitor shapes of X-ray pulses with lengths from units up to nanoseconds, a fast-acting fiber-optic scintillation detector is available in the MD set. The detector is characterized by increased noise immunity to magnetic pickups of pulsed physical facilities and does not require application of high-volt power supply sources. It contains a subnanosecond scintillator SPS-B18 [7] with diameter and height of 50 mm, dual plastic fiber-optic cable with a strand diameter of 1 mm, pin-photodiodes of ФД-271 type and a subnanosecond amplifier on a GaAs-field-effect transistor. «Cherenkov» background in the cable, approaching up to 16% of the useful scintillation light signal, is registered separately with the aid of a parallel fiber-optic channel (without a scintillator) and is subtracted from the detected signal on the amplifier input. The amplifier's output is connected to the registrator. ARSA X-ray pulse oscillogram, registered on the oscilloscope LeCroy Wavemaster-8500A with the aid of fiber-optic detector, is given in fig. 3.

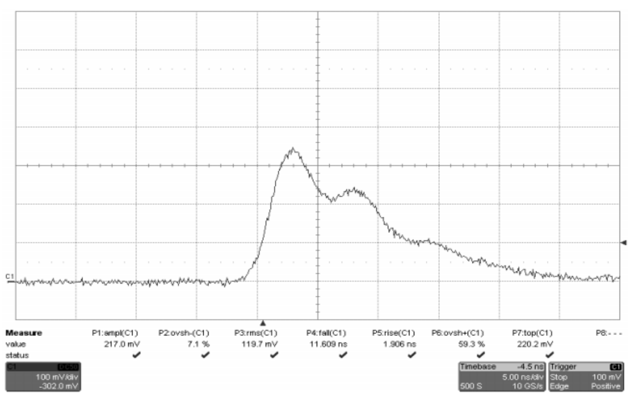

Figure 3: X-ray pulse shape of ARSA accelerator, registered with the aid of fiber-optic scintillation detector.

ARSA ACCELERATOR'S ADVANTAGES

A multi-year experience of ARSA accelerator's operation has revealed a number of their advantages with reference to other similar devices:

- high dose power (up to $5{\cdot}10^{10}$ cGy/s for X-ray radiation and up to $1{\cdot}10^{14}$ cGy/s for electron radiation),
- compact size and mobility,
- simplicity of operation and maintenance,
- good reproducibility of dose characteristics (±10 %),
- calculation of absorbed dose distribution in the irradiated object,
- varying of radiation type and parameters through a sealed tube change,
- long service life – up to 10^5 shots,
- rate of operation – hundreds of shots a day,
- ecology safety,
- electro-magnetic compatibility with electric equipment (developed level of electromagnetic interference in signal cables without special screening measures – not more than 0.2 V).

REFERENCES

[1] A.M. Chlenov, N.G. Mordasov, D.M. Ivashchenko, VANT, Phys. Rad. Exp. 1, pp. 5-10, (2010).

[2] S.L. Elyash, L.P. Profe, VANT, Phys. Rad. Exp. 3, pp. 132-136, (2002).

[3] S.L. Elyash, N.I. Kalinovskaya, Ye.N. Donskoy, et al., At. Energy 79, 6, pp. 462-464, (1995).

[4] S.L. Elyash., N.I Kalinovskaya, V.F. Goncharova, et al., Proceedings of the 7th International Conference on Electron-Beam Technologies EBT, Varna, Bulgaria, p. 591, (2003).

[5] E.A. Avilov, A.L. Yuryev, Prib. Tekh. Eksp. 2, p. 78, 2000.

[6] S.L. Elyash, A.V. Rodigin, V.A. Pikar', RF u. m. patent # 90575 (2009).

[7] T. Zoufal 1, K. Wick., Nucl. Phys. B 208, pp. 471-475, 2003.

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