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ANALYSIS OF HEAVY ION IRRADIATION FIELD NONUNIFORMITY USING TRACK DETECTORS DURING ELECTRONIC COMPONENTS TESTING

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Abstract

Determining the applicability of electronic components in spacecrafts involves conducting the tests using heavy ions. The Branch of URSC - ISDE and FLNR of JINR have created and operate the only in Russia test facilities based on the FLNR JINR accelerators allowing for heavy ion irradiation over a large area up to 200x200 mm. During simultaneous irradiation of several electronic components with heavy ions, it is necessary to ensure the device under test (DUT) location within the area of minimal nonuniformity. This problem is being solved by pretest determination of the irradiation field nonuniformity for each type of ion (Ne, Ar, Kr, Xe, Bi) and nonuniformity validation every 12 hours. Fluence is determined by a metrologically certified method using track detectors. In order to visualize the irradiation field nonuniformity, additional experiments were carried out with the irradiation of track detectors covering the entire irradiation area for each ion species. Based on the data obtained, a map of nonuniformity was plotted, which allows us to conclude that nonuniformity does not exceed 10% in the most frequently used areas of the irradiation field (100x150 mm) during SEE testing.

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This report presents the results of analysis of heavy ion irradiation field nonuniformity at various flow densities in test facilities to control resistance of electronic components (EC) to heavy ions (HI).

The assessment of the EC resistance to the effects of space ionizing radiation (SIP) is an integral part of the EC certification process for space applications. The procedure for confirming the EC resistance to the effects of SIP includes EC testing for single event effect assurance.

At this moment The Branch of URSC - ISDE and FLNR of JINR have created and operate the only in Russia test facilities (TF) based on the FLNR JINR accelerators allowing for heavy ion irradiation over a large area up to 200x200 mm.

The TF provides testing of all functional classes and constructive-technological versions (with the rarest exception) EC to all types of SEE. The TF allow to irradiate EC samples with C, O, Ne, Ar, Fe, Kr, Xe, Bi ions with a flux density in the range from 10 to 10^5 particles / ($cm^2 \cdot s$). Fluence is determined by a metrologically certified method using solid-state track detectors (TD) made of polymer membrane (Polyethyleneterephthalate and polycarbonate). TD are detectors of charged particles and nuclear fragments, the registration of which is accompanied by the appearance of observable tracks repeating the trajectory of the particle.

The main goal of the further development TF is to increase their availability, stability of work, accuracy of characteristics control and, as a result, informativeness and reliability of tests, while reducing the cost of conducting them.

In the same time during simultaneous irradiation of several electronic components with heavy ions, it is necessary to ensure the device under test location within the area of minimal nonuniformity. This problem is being solved by pretest determination of the irradiation field nonuniformity for each type of ion (Ne, Ar, Kr, Xe, Bi) and nonuniformity validation every 12 hours.

To visualize irradiation field nonuniformity, additional experiments were performed with irradiation of the TD covering all irradiation area at the beginning, middle and at the end of the session on each type of ion at four flow densities (Table 1). In order to take a photo of the tracks and then count them, the irradiated samples were etched in an alkali solution, for the manifestation of “hidden” tracks left by the particles, after which a gold layer was applied to obtain a contrast image created on the computer screen with an electron microscope. Next, the tracks were counted using an electron microscope in accordance with the metrologically certified “Method for measuring the fluence of heavy charged particles using track membranes based on polymer films”.

Table 1: List of Flux Densities Used During Irradiation of Detectors

No. of density	Flux density φ, [particles/(cm2×s)]	Fluence Φ [particles/cm2]
1	500	$3x10^5$
2	5000	10^6
3	10000	10^7
4	50000	10^7

Based on the data obtained, a map of nonuniformity was plotted (Fig. 1). The typical shape of the ion beam is in the form of a “Gaussian” curve with a “plateau” that is clearly distinguished in the central region of irradiation.

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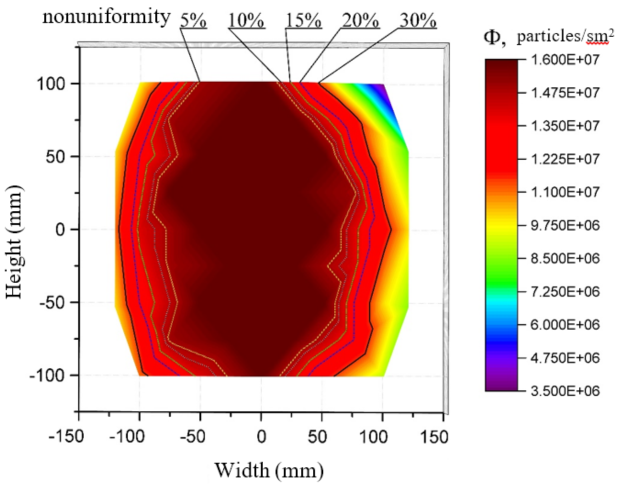

Figure 1: Beam profile with designated zones of nonuniformity.

Based on the map of nonuniformity, it can be concluded that in almost the entire irradiation area (150x200 mm) a nonuniformity of no more than 30% is provided. However, regardless of the entire irradiation field nonuniformity in the standard zone (100x150 mm) of the samples location (Fig. 2), the nonuniformity does not exceed 10%.

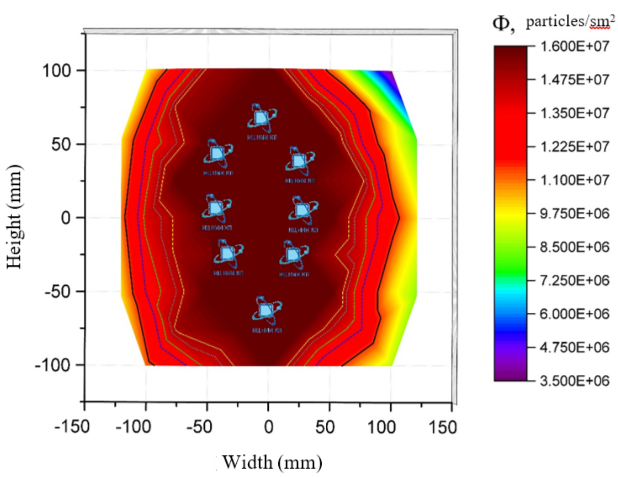

Figure 2: Beam profile with recommended sample area.

CONCLUSION

The results of the experiments will allow to optimize the process of testing, by making adjustments in the method of determining the nonuniformity of the irradiation field and calculating the conversion factor of online and track detector readings, and choose ways to upgrade the TF.