Individual and grouping track pits etched in the exposed in a free space plastic track detectors

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Abstract. New results concerned to the investigation of depth-dependent the pit-like surface-average and the grouping track-density distributions in the cosmic ray exposed column of CN-85 and CR-39 plastic solid state nuclear track detectors (SSNTD) are presented. Two main sources: solar cosmic ray protons and recoil nuclei for very short (length <3 μm) track-pit formation are considered. Theoretical estimation of the total, uniform track-pit density indicates on failure of evidence of some additional radiation effects, partially, hypothetically conditioned with the Erzion theory. Some quantitative proofs of this hypothesis have been obtained in the measurements of the pit-groups. Totally, up to this time it was registered near of 30 pit groups with the surface pit-density in the interval of (1 -15) x 10⁶ cm⁻², that is two-three orders of magnitude higher than uniformly distributed track-pits on the same CR-39 plate surface. As a result of layer-by-layer investigation of the exposed CN-85 stock arrangement three pit swarms exactly correlated with the end point of high ionizing primary charge particle tracks were observed. Obtained data are considered in according to submission based on the probability of detection for the negative charged cosmic ray Erzion particles stopping events.

1. Introduction

Further investigations of the firstly observed tracks [1] in the film piles of plastic SSNTD exposed in a free Space on the satellite orbit were undertaken. The satellite exposed in 1995 year column FB-19 was used. The new kind of tracks – pits, tracks with specific pit form and very small size was discovered. For their study the depth in stacks of cellulose nitrate CN-85 intensity distribution of such pits were measured. Explanation of the origin and nature of these tracks with help of the suggested cosmic ray Erzion mechanism was carried out [2-4]. The new results of the pit-groups observation in the film piles of plastic SSNTD CN-85 and CR-39, exposed by the cosmic ray, are presented. The same plastic SSNTD technique with the help of CR-39 particle detector has been used in electrolysis experiments [5].
2. Surface-average pit-like tracks

In Table 1 the results of the track-density, obtained by means of an optical microscope measuring, for the two pit groups with different diameters (D) are presented.

Table 1. Track-density ($\rho$, cm$^{-2}$) of pits of different diameters, observed on the CN-85 plate surfaces from the satellite exposed column FB-19.

| D, μm | 2  | 5  | 10 | 20 | 25 | 30 |
|-------|----|----|----|----|----|----|
| 1-2   | 8.1±0.5 | 3.9±0.3 | 3.5±0.3 | 3.0±0.3 | 2.8±0.3 | 2.4±0.25 |
| 3-4   | 2.5±0.25 | 1.5±0.2 | 0.8±0.1 | 0.6±0.04 | 0.25±0.03 | 0.28±0.03 |

(*): Track-pits were detected and accounted in 1000 microscope field of view with the surface screen element area $S_{n=1} = 4 \times 10^{-6}$ cm$^2$.

For precise interpretation of the obtained FB-19 column-depth track-pit density distribution there were considered two main very short (length $L < 3$ μm) track sources: a) possible formation of chemically etched tracks from the solar cosmic ray protons before their stopping in CN-85; and b) formation of short tracks due to recoil nuclei. In Table 2 the results of theoretical estimation of the surface pit-density, which can be formed by the stopping cosmic ray protons, are presented.

Table 2. Theoretically estimated numbers of the cosmic ray protons stopping in the layers of $h \sim 10$ μm on the head and lower surfaces of CN-85 in FB-19 column.

| Number of plate in the column | $E$, MeV (*) | $J$, proton fluence | Track-pit density (****) $\times 10^2$ |
|-------------------------------|-------------|-------------------|----------------------------------|
|                               | head | lower | head | lower | head | lower | head | lower |
| 2                             | 2.8  | 4.3   | 30.0 | 8.3   | 11.4 | 3.15   | 6.56 | 1.81   |
| 5                             | 6.4  | 7.4   | 4.3  | 3.7   | 1.63 | 1.41   | 0.73 | 0.63   |
| 10                            | 10.2 | 10.8  | 2.7  | 3.0   | 1.03 | 1.14   | 1.43 | 1.58   |
| 15                            | 13.1 | 13.6  | 3.7  | 3.9   | 1.41 | 1.48   | 1.96 | 2.06   |
| 20                            | 15.5 | 16.0  | 4.25 | 4.35  | 1.61 | 1.65   | 2.24 | 2.29   |
| 25                            | 17.5 | 18.0  | 4.6  | 4.7   | 1.75 | 1.79   | 2.43 | 2.49   |
| 30                            | 19.6 | 19.9  | 5.05 | 5.1   | 1.92 | 1.94   | 2.67 | 2.70   |

(*) Energy of protons, at which they run up to head and lower surfaces of each plate;
(**) Flow of the solar and galactic cosmic ray protons $J$ in units of (cm$^{-2}$ s sr MeV)$^{-1}$;
(***) Flow of protons $J_{70,2x} \times 10^3$ in units of (cm$^{-2}$ MeV)$^{-1}$, corresponding to 70 days of FB-19 exposure;
(****) The surface track-pit density of D = 2-3 μm (in units of cm$^{-2}$).

Solid stream of the solar and galactic cosmic ray protons during of FB-19 70 days exposure at $2\pi \cdot sr$ equal to $J_{70,2x} = 3.8 \times 10^7$ proton $\times$ (cm$^{-2}$ sr MeV)$^{-1}$. The effective thickness of plate surface, in which the stopping protons can be registered as short pit-like tracks, estimated from the data: $\rho = J_{70,2x} \times \Delta E$, where $\Delta E$ – energy interval, corresponding to plate layer thickness of $\Delta h \approx 2D$ that is smaller of 5 μm, and in average for used CN-85 is equal to $5 \times 10^2$ MeV. The surface track-pit density of D = 2-3 μm lies in interval of $(2-6) \times 10^2$ cm$^{-2}$. Comparison of these results with the experimental data, equal to $(2.4-8) \times 10^2$ cm$^{-2}$, indicate, that contribution of stopping cosmic ray protons in observed track-pit density of D = 2-3 μm is by two-three orders of magnitude lower than the experimentally registered values.
Results of the theoretical estimation of the possible addition formation from the pit-like track-density of \( D = 2-3 \mu m \), which can be formatted by the recoil nucleus in CN-85 plates, is practically the same for pits of experimentally determined values. Thereby, the precision investigation of depth-dependent the pit-like surface-average track density distribution indicates on the non-registrability of some additional radiation effects, partially conditioned with the Erzion hypothesis. For further check of the pit nature it has been executed the precise investigation of a large square in the films of plastic SSNTD CR-39 and CN-85 from the different piles and satellite flights [1].

3. Pit swarms observation on the PSSTD CR-39

On the total about 50 cm\(^2\) searched plate surface it was discovered a range of the specific compact pit groups. The spatial and quantitative characteristics of these pit groups indicate that their sources are the swarms of the not-knowing origin particles formed in the track-detector matter. All determined pits were separated in three groups due to their spread in the plastic surface intervals: 0.5-1, 1-2 and 2-3 \( \mu m \). Relative number of these pit-types in different pit-groups is varied. In figure 1 three examples of pit-track groups of the very different kinds are shown. In each of the observed track-pit groups it was recorded near 100-200 pits that corresponding to the surface density of \((2-10) \times 10^6\) cm\(^{-2}\). These values in comparison with the average pit-like points on the same surface of CR-39 plate by two-three orders of magnitude are higher.

![Figure 1](image-url)

**Figure 1.** Graphic presentation of three pit-track groups, observed on the chemically etched surface of CR-39 exposed in cosmic space. A small square 5 × 5 \( \mu m \) is represented by diagram.

3. Pit swarms observation on the PSSTD CN-85

With the purpose of detection of events of the nuclei stops and, if it is probable, collinear set of the congestions located pits there is begun detailed viewing and analyzing of the No 2-5 CN-85 plate surfaces from an assemblage of FB-19 (see figure 2). By present time it was examined about 5 cm\(^2\) from the total area of the pile of 18 cm\(^2\). As a result of the layer-by-layer investigation of the exposed in FB-19 stack assemblage PSSTD CN-85, three pit swarms exactly correlated with the end of track formed by high ionizing primary charge particle were observed.

One of the more substantial and certainty occurrence, when the congestion of the pit groups of different diameters (from 1-2 \( \mu m \) up to 8-10 \( \mu m \)) precisely corresponds to a moving direction of the charged stopped in the plate CN-85 particle, was found. This event of relative positioning of the track and pit group, generated on two surface sites of the plates No 4 (the bottom surface) and No 5 (the top surface), schematically is shown in figure 2.
The results of detail examination of CN-85 No 2-5 plates are the next: 1) The pit densities of the diameter 1-2 μm and 8-10 μm for the plate No 4 (foot) in the area ~3 × 10^{-4} cm^2 are ~1 × 10^5 cm^{-2} and ~4 × 10^4 cm^{-2}, correspondingly. An average pit densities, representing the surrounding background, are equal to (1-2) × 10^3 cm^{-2} and (1-2) × 10^2 cm^{-2}. Thus, it is important to note, that on a corresponding site of the top surface of the plate No 5 the number of pits in a congestion in 2-3 times below.

2) Prominent feature of a registered track is absence narrowed to a point of a stop of a track etching cone, which usually is observed for positively charged ions. It allows us to assume in the first approximation, that observed in given case the track, was formed by negatively charged nucleus particle.

4. Conclusion
For the first time in the film-plates of the plastic SSNTD CN-85 and CR-39 exposed in different piles and satellite flights the specific track-pit swarms were detected. The number of these swarms is equal to some tenths per squire centimeter of the plate surface under investigation. The origin and the nature of these track-pit swarms can be examined as the results of stopping events of negative charged cosmic ray Erzions, the nature of which theoretically have been considered in the frame of model of the cold nuclear transmutation [2-4].

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