DETECTORS OF CHARGED PARTICLES AND LOW-ENERGY GAMMA-QUANTA ON THE BASIS OF TICOR SINGLE CRYSTALS

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Scintillation characteristics have been studied for detectors of charged particles and low-energy gamma-quanta produced on the basis of Ticor single crystals.

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1. INTRODUCTION

Scintillators based on Ticor (Al_2O_3:Ti) are known as materials for detectors of short-range ionizing radiation that are distinguished by their high chemical, thermal and radiation stability. The present work was aimed at studies of scintillation characteristics of both single crystalline and polycrystalline scintillators based on Ticor for detection of α-particles from ^{238}Pu and γ-quanta from ^{241}Am.

2. DETECTORS AND EXPERIMENT

Studies have been carried out of single crystalline samples in the geometry of rectangular plates, discs and truncated pyramids, as well as of detectors based on composition materials comprising polycrystalline Ticor scintillators and organic binders.

Scintillation characteristics of detectors were measured using a spectrometric circuit that included a charge-sensitive preamplifier of PU-G-1K-2 type, a linear amplifier of BUS2-97 type and a multi-channel pulse amplitude analyzer of AI-1024-95 type. As photoreceiver, we used an R 1307 Hamamatsu PMT with photocathode diameter of 3". The signal integration constant (*RC*) was 8...12 μs.

For excitation of the detectors, we used α-radiation sources of OSAI type ($A=10^4$ Bq) and γ-radiation sources of OSGI type ($A=10^5$ Bq). A collimator with one or two openings was placed between the detector and α-radiation source.

We have compared characteristics of a single crystalline detector shaped as a rectangular truncated pyramid, dimensions of the basements 25x8 mm and 15x5 mm, height – 30 mm, another single crystalline detector shaped as a rectangular plate 10x10x1 mm, and a polycrystalline composite detector (disc-shaped, ∅ 40x5 mm).

Fig.1 shows the pulse amplitude spectrum obtained from the rectangular Ticor plate under excitation by α-particles from ^{238}Pu (E_α=5,5 MeV) using a collimator with one opening.

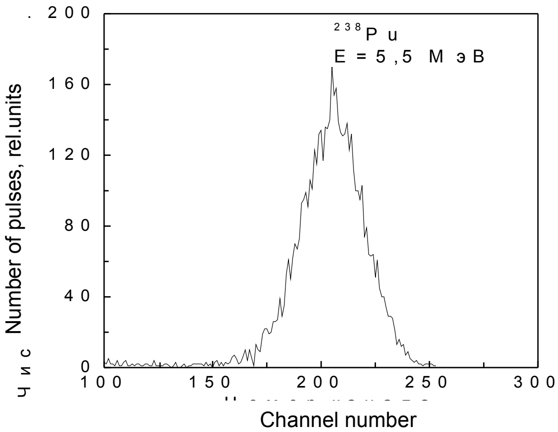


Fig.1. Pulse amplitude spectrum from Ticor-based single crystalline detector, dimensions 10x10x1 mm, under excitation by a-particles from ^{238}Pu

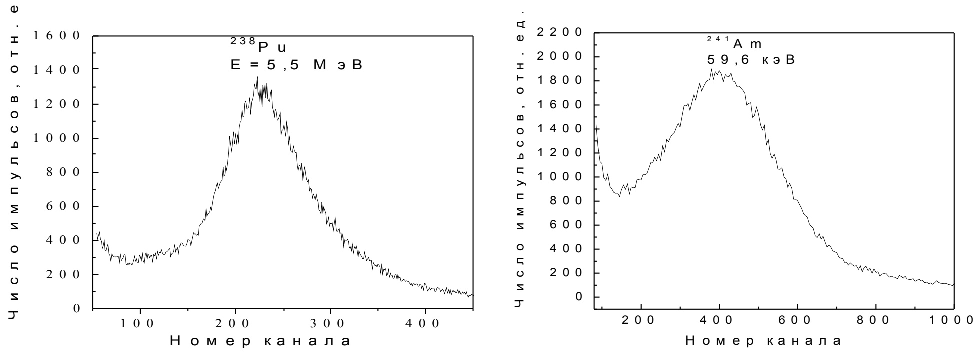
The energy resolution R_α value at this energy was 16.5%, and the α/β–ratio for the crystal was 0.64.

The α/β–ratio depends, finally, on the irradiation geometry, light collection coefficient and pulse characteristics of the spectrometer used. Thus, under α-irradiation of the upper base of the truncated pyramid the α/β–ratio was 0.34, while for the side surfaces this value was 0.46. At the same time, with the rectangular plate at *RC* = 8 μs the α/β–ratio value was 0.64, and at *RC*=12.8 μs – 0.75.

In this relationship, of substantial interest were also the composite detectors based on Ticor. In Fig.2, characteristics are shown for such a detector under irradiation by α-particles from ^{238}Pu and γ-quanta from ^{241}Am (E_γ=59.6 keV).

The values of R_α= 48-49% at R_γ =96.5%, that is quite satisfactory for composite detectors of this type.

According to the calculated and experimental data given in [1], The paths of fission products of heavy nuclei ^{233,235}U, ^{239}Pu with mass numbers from 131 to 136 were from 3.095 to 3.60 mg/cm^2. Data obtained in [2] on the sensitivity of Ticor scintillation single crystals to ion radiation show a possibility to use these crystals for detection of fission products.



a) *b)*

Fig.2. Pulse amplitude spectra from a Ticor-based composite detector of dimensions ∅ 40x5 mm under excitation by α-particles from ^{238}Pu (a) and γ-quanta from ^{241}Am (b)

Screen material	Activator content, mass %	Threshold sensitivity, protons/cm^2	Light yield, photons/proton·s	Afterglow in 60 μs, %	Radiation stability threshold, protons/cm^2
$Al_2O_3:Cr^{3+}$ single crystal	0,066 0,08 1,10	$1{,}7\cdot10^6$ $2{,}0\cdot10^6$ $2{,}8\cdot10^6$	440 377 263	8...10 2...4 50	$10^{18}...10^{19}$ $10^{18}...10^{19}$ $10^{18}...10^{19}$
$Al_2O_3:Cr$ ceramics AF 995	0,1	$4{,}5\cdot10^6$	159	-	$10^{18}...10^{19}$
$Al_2O_3:Ti^{3+}$ single crystal	0,011 0,047	$1{,}9\cdot10^7$ $2{,}7\cdot10^7$	39 27	1 1	$10^{18}...10^{19}$ $10^{18}...10^{19}$
ZnS	-	$3{,}0\cdot10^7$	8...16	-	$<10^{15}$
BeO ceramics	-	$4{,}7\cdot10^8$	1,6	-	$>10^{18}$

In the table, characteristics are shown of screens on the basis of doped sapphire under excitation by proton beams of E_p=70 GeV energy and density $10^{12}...10^{14}$ protons/cm^2, pulse duration 10^{-6}...0.4 s and period of 8 s. For comparison, the data for screens based on other materials are presented.

3. CONCLUSIONS

As a result of our studies, we have shown in principle a possibility to use scintillation single crystals of Ticor for detection of charged particles and low-energy gamma-quanta.

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ДЕТЕКТОРЫ ЗАРЯЖЕННЫХ ЧАСТИЦ И НИЗКОЭНЕРГЕТИЧЕСКИХ ГАММА-КВАНТОВ НА ОСНОВЕ МОНОКРИСТАЛЛОВ ТИКОРА

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В работе представлены результаты исследований сцинтилляционных характеристик детекторов заряженных частиц и низкоэнергетических гамма-квантов на основе кристаллов тикора.

ДЕТЕКТОРИ ЗАРЯДЖЕНИХ ЧАСТОК І НИЗЬКОЕНЕРГЕТИЧНИХ ГАМА-КВАНТІВ НА ОСНОВІ МОНОКРИСТАЛІВ ТІКОРУ

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У роботі представлені результати досліджень сцинтиляційних характеристик детекторів заряджених часток і низькоенергетичних гамма-квантів на основі кристалів тікору.