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New scintillation materials and scintiblocs for neutron and γ-rays registration

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Abstract

This paper is a short review of some new scintillation materials, scintillation detectors and scintillation systems for registration of gamma-rays, X-rays, neutrons and neutrinos, which have been developed on the level of inventions and a new fundamental level in the Ural State Technical University-UPI (Ekaterinburg, Russia) and Laboratoire de Physico-Chimie des Matériaux Luminescents (Université Lyon 1, France). The part of Russian patents for this area are presented: some most important new scintillation materials (on the base of lithium hydride, silicate compounds, compounds on the base of aluminates, compounds on the base of fluorides and oxyfluorides, compounds on the base of oxides and oxides crystals, glasses and transparent ceramics) and new scintillation devices (on the base of HgI_2, on the base of $LiKSO_4$, sandwich-detectors (organic–inorganic–glass–fiber materials), combine detectors, detectors with photodiodes registration and spectrum shifter, surface scintillation structures and screens, and fiber scintillation devices).

PACS: 70

Keywords: Single crystals; Color centers; Radioluminescence; Scintillation materials; Geterostructures and screens; Radiation detectors for neutrons; X-rays; γ-Rays; Neutrinos

1. Introduction

The scintillation method is still one of the main methods used for registration of ionizing radiations. The universality of this method is considered

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to be its main advantage. It can be used for registration of almost all types of radiation in a wide range of energy (varying 1 eV–10 GeV), including, for instance, supersoft β-radiation of isotopes ^{3}H and ^{14}C and superhard radiation of accelerators. Advantages of the scintillation method are enlarged by the possibility of its use as scintillation indicators and screens. In this connection single crystals, fiber crystals, films scintillation and combined scintillation detectors are widely used in nuclear physics, physics of high energies, geophysics, biophysics, biochemistry, radiochemistry, medical radiation, for equipment and industrial complexes of nondestructive radiation control as well as in these ones of radio ecological monitoring of areas, water and territories.

2. Scintillation materials (compounds)

The development of scintillation devices described below was conducted according to the world data as well as for to the information worked out on the patent level in USTU-UPI. The short list of the most important materials developed in USTU-UPI is given below accompanied by the numbers of Author certificates (A.c. of USSR) and dates of their registrations.

2.1. Compounds on the base of lithium hydride

LiH–Bi,Mg	A.c. No318302	1971,
LiH–CeF_3	A.c. No430736	1974,
LiH–Eu,Gd,CeF_3	A.c. No743407	1980,
Li(H,D)–Mg	A.c. No826765	1981,
LiH and LiD	A.c. No1075756	1983,
LiD	A.c. No1317995	1987.

2.2. Silicate compounds

$Na_2Zr(Hf)SiO_5$–Ln	A.c. No238058	1968,
$Ba_2Zr(Hf)Si_3O_9$–Ln	A.c. No245252	1969,
$Ba_2Zr(Hf)_2Si_3O_{12}$–Ln	A.c. No320520	1971,
$Ba_2Zr(Hf)_2Si_3O_{12}$–Ln	A.c. No353578	1972,
$ZrSiO_4$–Ln	A.c. No403317	1973,
$ZrSiO_4$–Ln	A.c. No436609	1974,
$Ca_3ZrSi_2O_9$–La,Ti,Pb	A.c. No488496	1975,
$Na_{14}ZrSi_{10}O_{31}$–Ln	A.c. No490355	1975,
$Na_{14}HfSi_{10}O_{31}$–Ln	A.c. No490355	1975,
$Na_4Zr_2Si_3O_{12}$–Ti	A.c. No664366	1979,
Na_2ZrSiO_5–Eu,Sm	A.c. No671502	1979,
$ZrO_2 \cdot SiO_2 \cdot Na_2O$	A.c. No722417	1979,
Sc_2SiO_5–Gd	A.c. No1382207	1987,
Y_2SiO_5–Ce,Tb	A.c. No1517573	1989.

2.3. Compounds on the base of aluminates

$BeO \cdot Al_2O_3 \cdot SiO_2$	A.c. No785824	1980,
$Y_3Al_5O_{12}$–i,Cu	A.c. No900706	1981,
$Y_2O_3 \cdot Al_2O_3 \cdot Pr_2O_3$	A.c. No1059882	1983,
$LiAlO_2$	A.c. No1136627	1984,
$Lu_3Al_5O_{12}$	A.c. No1259831	1986,
$CaAl_4O_7$	A.c. No1289224	1986,
$CeMgAl_{11}O_{19}$	A.c. No1322830	1987.

2.4. Compounds on the base of fluorides and oxyfluorides

YOF–Tb	A.c. No577804	1977,
$SrF_2 \cdot CeF_3 \cdot EuF_3$ (CdF_3,DyF_3,TbF_3)	A.c. No738453	1980,
LiF–$UO_2(NO_3)_2$	A.c. No1304584	1986.

2.5. Compounds on the base of oxides and oxides crystals

$EuTiNbO_6$	A.c. No321893	1971,
$Y_{0,5}Eu_{0,5}TiNbO_6$	A.c. No323429	1971,
$CsCaVO_4$	A.c. No403315	1973,
$EuTiTaO_6$	A.c. No403316	1973,
$Zn_3Mo_2O_9$–Ln	A.c. No439215	1974,
$BeO \cdot Cr_2O_3$	A.c. No702857	1979,
$Ca_3(VO_4)_2$	A.c. No723470	1979,