Our proposal is related to the development of the new types of luminescent materials, based on the solid solutions of mixed orthosilicate and garnet compounds, prepared in the form of ***composite film-crystal epitaxial structures*** using Liquid Phase Epitaxy (LPE) growth method. We focus our attention on the development of scintillating and thermoluminescent (TL) materials, which can transform ionizing radiation in the visible or UV light. Apart from the scintillating and TL detectors, the fields of application of the compounds under study include also the cathodoluminescent screens, laser media, and photoluminescence converters for white LED, etc.

Recently, mixed crystals have become an important trend in scintillator development aiming at the materials with higher light yield and better energy resolution. During the last ten years, series of new scintillation materials based on mixed crystals with superior light yield and very high energy resolution have been introduced. Namely, the crystals based on the solid solutions of $(LuY)_2SiO_5$:Ce (LYSO:Ce) and $(LuGd)_2SiO_5$:Ce (LYGSO:Ce) orthosilicates are also the well-known scintillators for the Positron Emission Tomography with a light yield of 35000-45000 photon/MeV. The Ce doped $(Gd,Lu)_3(AlGa)_5O_{12}$ and $(Gd,Y)_3(AlGa)_5O_{12}$ garnets present now the novel class of efficient and fast scintillators. The light yield of these scintillators in the crystal form can reach the extremely high values 60000-65000 photon/MeV.

LPE method open the possibility of creating the composite scintillators of “phoswich-type” (phosphor sandwich) for registration of the different components of ionizing radiation, namely, for analysis of the content of mixed fluxes of particles and quanta with various penetrating depths. Such composite scintillators present the epitaxial crystalline structures, including one or two single crystalline films intended for registration of low penetrating α- and β-particles, and bulk single crystal substrates for registration of the high penetrating radiation (X- or γ-rays).

Fast development of microimaging techniques with traditional X-ray sources or synchrotron radiation in the X-ray range for applications in biology, medicine and industry also need creation of X-ray image detectors with spatial resolution in the μm range. For this purposes, the visible emitting scintillating screens based on the thin (up to 20 μm) single crystal and single crystalline films of Ce^{3+} doped YAG and LuAG garnets, as well as single crystalline films of Eu^{3+} and Tb^{3+} doped LuAG and GGG garnets and Ce^{3+}, Tb^{3+} doped LSO orthosilicates have been developed using the LPE method in the last decade. Meanwhile, the possibility of receiving the highest spatial resolution of X-ray images even in the submicron range strongly demands development of new thin (a few μm) scintillating film screens with extremely high absorption ability of X-rays, which is proportional to ρZ^4, where ρ is the density and Z_{eff} is the effective atomic number of scintillators. It is better also to choose the emission spectrum of new film scintillation screens in the blue or ultraviolet (UV) range because their spatial resolution is proportional to λ, according to formula $\mathbf{0.61*\lambda/N_A}$, where λ is the emission wavelength, N_A is numerical the aperture of the optics.

The LSO, LGSO, LuAG and LGAGG hosts also have significantly higher density (6.74-7.4 g/cm^3) and effective atomic number (61-66) as compared to the commonly used YAG and GGG garnets for producing of single crystalline film scintillators. Therefore, the solid solutions of Lu-Gd–Tb based orthosilicates and garnets are also very promising materials for creation of single crystalline film scintillators, emitting in the blue and near UV range, for visualization of X-ray images with higher (in the submicron range) spatial resolution. From dopants, which effectively emit in the near-UV and visible ranges in the mixed orthosilicate and garnet hosts, mainly Ce^{3+}, Tb^{3+} and Eu^{3+} ions can be used.

In our project we will use the LPE method for development of the novel types of composite detectors, namely: 1) the composite film-crystal scintillators based on the solid solution of Ce^{3+} doped $Lu_{2-x}R_xSiO_5$ (R=Gd, Y; x=0÷2) orthosilicates and $Lu_{3-x}R_xAl_{5-y}Ga_yO_{12}$ (R= Gd, Tb, Y; x=0÷3; y=0÷5) garnets; 2) the composite film-crystal scintillating screens based on the solid solution of mentioned mixed orthosilicates and garnets, doped with Ce^{3+}, Tb^{3+} and Eu^{3+} ions; 3) composite TL detectors based on the above mentioned Ce^{3+}, Tb^{3+}, Eu^{3+} and Mn^{2+} doped mixed orthosilicates and garnets. For LPE growth of composite detectors, the respective substrates producing from Ce^{3+} doped crystals of YSO, LGSO, LGSO orthosilicates and YAG, LuAG and GAGG garnets will be used.

We also plan to compare the scintillating and thermoluminescent properties of the single crystalline films of mentioned mixed orthosilicate and garnet compounds with the properties of their bulk crystal analogues, grown by the micropulling down (MPD) and Czochralski methods.

As relatively novel research approach at the creation of scintillation and TL materials, we try to apply in the project combination of the “band-gap engineering” and “engineering of the positions of activator radiative levels in band gap” as well as “enhancement of the energy transfer efficiency in rare-earth cations sublattices” to the basic scintillation materials - the LSO and YSO orthosilicates and YAG and LuAG garnets, doped with Ce^{3+} , Tb^{3+} and Eu^{3+} ions, using alloying with Gd^{3+} and Y^{3+} ions in the different cation positions of silicate hosts and Gd^{3+}, Tb^{3+}, Y^{3+} and Ga^{3+} ions into the different cation positions of the garnet hosts. Such „engineering” of the energetic structure of the matrixes and mentioned activators in them can resulted in decreasing or increasing of the influence of the host defects and dopants on the scintillating and TL processes and leads to the optimization of the properties of scintillators and TL materials.

The combination of the cation content in the mentioned mixed orthosilicate and garnet compounds opens also the possibility of creation of the wide sets of composite-film scintillators and TL detectors with different absorption ability of α- and β-particles and X- and γ-rays. This is necessary for the various kinds of applications of such scintillators and TL detectors for environmental radiation monitoring and security scanners as well as the 2D/3D imaging in microtomography, nondestructive testing in industry, biology, medicine, paleontology, etc.