The aim of the project is to ***develop composite multilayer fiber-optic detectors (FOD) exploiting the optically stimulated luminescence (OSL) and scintillation phenomena for active in-situ radiation dosimetry in radiotherapy and nuclear medicine applications*** with the particular aim of ***simultaneous registration of different types of ionization radiations.*** The materials under study will be crystals, single crystalline films and composite film-crystal structures based on the rare-earth (Ce, Pr) and transition metal (Mn) doped complex oxides, like heavy mixed $(Y,Lu)_3(Al,Ga,Sc)_5O_{12}$ garnets and $(Y,Lu)AlO_3$ perovskites as well as tissue-equivalent $MgAl_2O_4$ spinel and Al_2O_3 sapphire. The main technique technique for creating composite detectors will be the ***liquid phase epitaxy (LPE) growth method***. In our project, we will study LPE growth processes of the doped films of mentioned oxides onto substrates, prepared from the undoped and Ce^{3+} doped crystals of $Y_3Al_5O_{12}$, $Lu_3Al_5O_{12}$ and $Gd_3(Al,Ga)_5O_{12}$ garnets, Ce^{3+} and Pr^{3+} doped $YAlO_3$ perovskites, Mn doped $MgAl_2O_4$ spinel, and C and C, Mg doped Al_2O_3 sapphire, respectively, as well as we will investigate their luminescence, scintillation and dosimetric properties in comparison with crystal analogues of these materials grown by micro-pulling or Czochralski methods.

The operating principle of multilayer composite detectors is to use signals from different parts of the detector to register different components of the radiation field. However, the ***main challenge is to effectively separate signals originating in various layers after absorption of the different types of high-energy particles and/or quanta.*** It may be attempted using the *differences in positions of the main TL peaks* of films and crystal parts of composite detector ***(passive registration mode),*** *or difference in their luminescence spectra and decay kinetics* ***(active registration mode)***.

OSL is the modern dosimetric technique for *radiation measurements*, superseding older *passive* methods. However, the OSL limitation is a very narrow choice of existing materials, as only Al_2O_3:C and BeO detectors are commercially available and used in practice. However, ***we found recently the occurrence of intense luminescence under near-infrared stimulation (IRSL)*** in crystals of several Ce^{3+} doped garnets, such as $Gd_3Ga_{2.5}Al_{2.5}O_{12}$:Ce, $Y_3Al_5O_{12}$:Ce and $Lu_3Al_5O_{12}$:Ce, which are ***capable of measuring extremely low doses in the µGy range***. The promising intensity of IRSL are found also in Pr^{3+} and Ce^{3+} doped $YAlO_3$ perovskite and undoped $MgAl_2O_4$ spinels. Such recent discovery of bright IRSL in mentioned oxides, suitable also as substrates for production of composites using LPE growth method, created new possibilities for composite detector operation by exploiting ***differences in OSL emission and stimulation spectra***.

The scintillation properties of materials, like *intensity and emission spectra of radioluminescence (RL)*, can also be used to determine the radiation dose in the *in situ*-mode of registration. In this case, the RL light yield under high-energy excitation must be proportional to the radiation dose over a wide dose range (Fig.1). Furthermore, the *registration of luminescence spectra of different parts of the composite detector, originating from the various types of radiations*, ***is much better for in situ dose measurements than measuring of RL intensity***. Indeed, determination of the radiation dose of various types of radiation can be performed by measuring the intensity of the main RL emission bands or the area of the emission spectra corresponding to film and crystal parts of the composite (Fig.1).

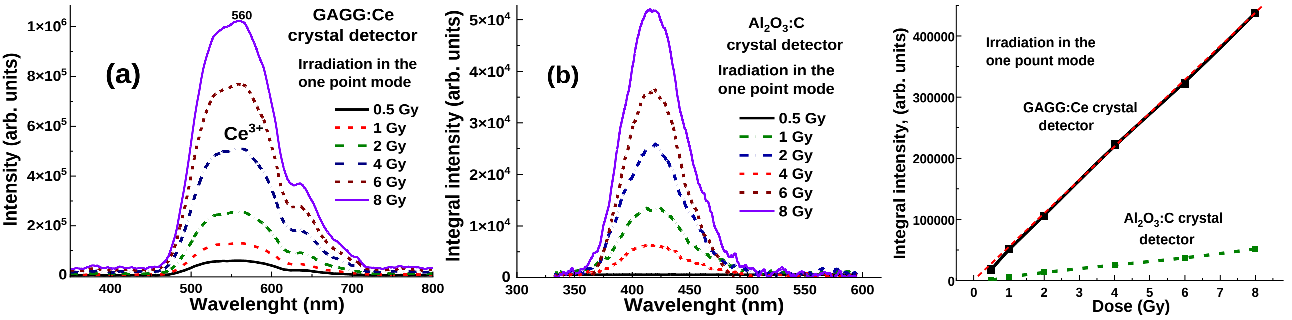

Fig.1. The result of in-situ dose measuring test at the Oncology center in Bydgoszcz at brachytherapy procedure with Flexitron Electra setup with ^{192}Ir γ-rays source and GAGG:Ce (a) and Al_2O_3:C (b) crystal detectors with 2*2*1 mm size: dependence of the intensity of the Ce^{3+} (a) and F (b) centers luminescence bands and integral LY in GAGG:Ce and Al_2O_3:C crystal detectors (c) on the radiation dose. The scintillation signal was registered by using2.5m long optical fiber and sensitive luminescence spectrometer.

Based on these considerations, our project will be a new advance in the development of multilayer composite luminescent materials working in active registration mode based on OSL and scintillation phenomena. Furthermore, the ***practical effect of our project will be the creation of composite FODs for real-time radiation dosimetry of various types of ionizing radiation in medical applications.*** Finally, an application-focusing test of the developed composite FODs for the actual tasks of radiotherapy and nuclear medicine, like boron neutron capture therapy (Fig. 2), radiation therapy with proton and mixed X-rays/electron sources, brachytherapy as well as radiation monitoring in direct contact with mixed liquid radioactive sources and wastes will be performed in the clinical conditions of the Oncology Center in Bydgoszcz.

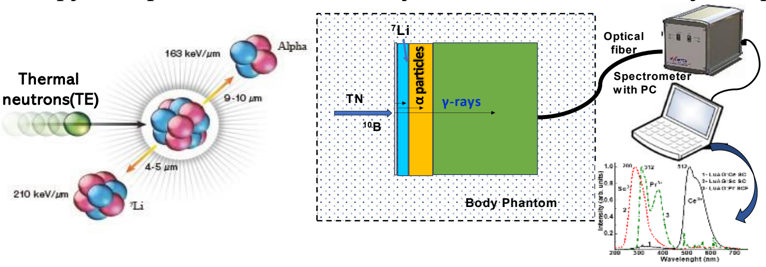

Fig. 2. The secondary nuclear radiations in BNCT and proposed scheme of composite dosimeter for recording dose from various types of ionizing radiation (^{7}Li ions, α-particles, and γ-rays).