In the recent years white light emitting diodes LED (WLED) lamps as solid-state light sources for the next generation of lighting have been displacing traditional light sources due to their advantages and unique properties, including high luminous efficiency, low electric consumption and energy saving, high brightness, long lifetime, small volume, environmental friendliness and price competitiveness against fluorescent lamps. The rate of the displacement for various applications such as backlighting for displays, automotive and general lighting depends on developing more powerful near UV and blue chips, more efficient PC and new conversion schemes of chip radiation to white light. It is assumed that for mass-producible 60W LED bulbs, the average luminous efficiency will increase from 75.8 lm/W in 2014 to 89.3 lm/W in 2017 by taking into account a practical efficacy limit to be 200 lm/W whereas the luminous efficiency of incandescent and fluorescent lamps are 15 and 75 lm/W, respectively. Replacing light bulbs and fluorescent tubes with WLED will lead to a drastic electricity reduction by taking into account that 20-30% of the electricity consumed in industrial economies is used for lighting.

At present a WLED source manufactured based on the blue LED chip and a yellow emitting YAG:Ce powder phosphor dispersed in plastic encapsulate resin like epoxy and silicone is a canonical device (Fig.1a). While a large number of different phosphors have been developed to date, YAG:Ce is still most popular phosphors for manufacturing WLED.

In the last years the so called Chip-Level-Conversion (CLC) design became accepted predominantly for the production of high power WLEDs (Fig.1b). The YAG:Ce ceramic is a promising candidate for a planar phosphor in WLEDs. The yellow emission band of the YAG:Ce ceramic is complementary to the blue light emitted by an InGaN LED, thus making white light when the ceramic thickness is around 0.4–0.6 mm. The emission color of such WLED can be changed by controlling the ceramic thickness. The highest reported value of the luminous efficacy of such device is 70 lm/W, which is comparable to that of commercial WLEDs.

For future developed CLC design for high-power WLEDs, we propose to use a new class of ceramics, phosphors based on Ce^{3+}, Eu^{3+} and Mn^{2+} doped $A_3B_2C_3O_{12}$ (A=Gd, Tb, Y; B=Al, Ga; C=Ga, Al) mixed garnets. Ceramics of these mixed rare-earth based garnets can possess some important advantages compared to the YAG:Ce ceramic due to additional channels for the excitation energy transfer from host to two or more dopant ions well as the conditions for the creation of multicolor emission under excitation by near UV or blue LED chips.

Aside of the ceramic phosphors, as a further development of the CLC concept, the use of epitaxially grown film and hybrid film-substrate phosphors is also considered in our project. The pioneering work here was carried out in our project. White light under blue LED excitation was obtained by providing a $\{GdY\}_3[Al,Ga]_2(Ga,Al)_3O_{12}$ and $\{TbGd\}_3[Al,Ga]_2(Ga,Al)_3O_{12}$ garnet film phosphors epitaxially deposited onto a YAG and YAG:Ce substrate to induce yellow and red emission. To our knowledge, this is the first effort to create a WLED by epitaxy of film converters using the YAG:Ce as substrate-converters.

From our knowledge, the development of PC based on the ceramics, films and film-crystals structures based on the Ce^{3+}, Eu^{3+} and Mn^{2+} doped $\{GdY\}_3[Al,Ga]_2(Ga,Al)_3O_{12}$ and $\{TbGd\}_3[Al,Ga]_2(Ga,Al)_3O_{12}$ mixed garnets hasn't been realized so far. We plan to perform this work at Department for Optoelectronic Materials of Institute of Physics UKW in Bydgoszcz taking into account that our group possesses longtime experience in the development of garnet phosphors and possesses different technological equipments for the preparation of mixed garnets in the various crystalline forms.

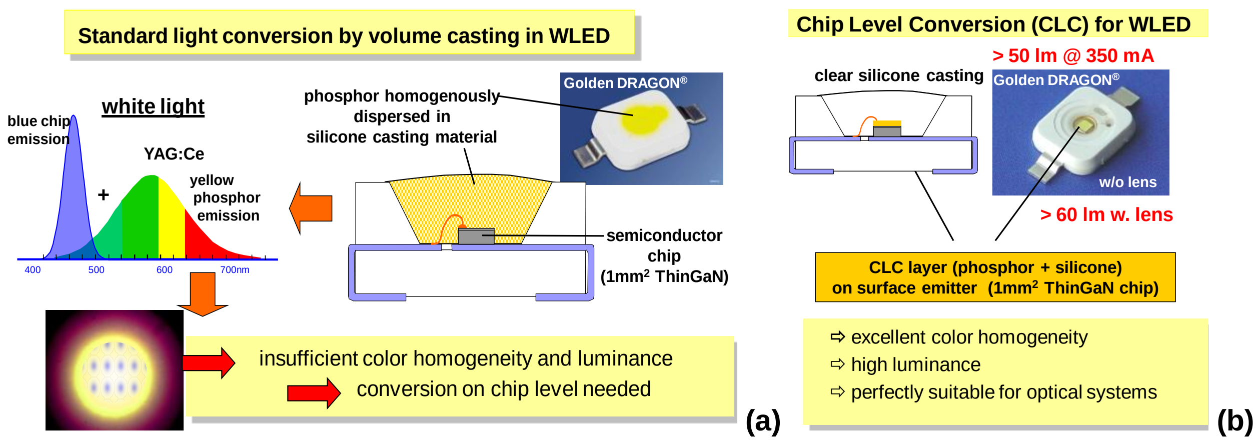

Fig.1 Typical Volume-Casting-Conversion design (a) and Chip-Level-Conversion (CLC) design (b) in WLED (https://www.osram.com/os/).