INVESTIGATION OF CERIUM AND BORON DOPED YTTRIUM AND LUTETIUM ALUMINUM GARNET CERAMICS

Greta Inkrataitė, **Ramūnas Skaudžius**

Institute of Chemistry, Faculty of Chemistry and Geosciences, Vilnius University,
Naugardukas st. 24, LT-03225 Vilnius, Lithuania
greta.inkrataite@chgf.vu.lt

INTRODUCTION

In order to convert high-energy radiation, such as gamma or X-rays, into a visible light, a certain type of material is needed. Such compounds are usually referred to as scintillators. Over the years many different candidates to fit the requirements were examined. However, compounds with garnet structure have attracted a particularly large amount of attention [1]. Cerium doped yttrium and lutetium aluminum garnets (YAG:Ce, LuAG:Ce), have high density, high thermal stability, a rather intensive emission/excitation and high quantum efficiency which are needed for a good scintillator. However, further optimization and improvement is still needed especially on the shortening of the decay time. One way to approach this problem is to alloy the aforementioned compounds with different elements, such as boron and magnesium [2,3].

In this work we describe the synthesized YAG and LuAG garnets that are doped with 0.5% cerium that are additionally doped with 5% of boron and / or 0.03% of magnesium. The initial powders of garnets were synthesized Sol-Gel method. Ceramics were obtained using hydrostatic pressure. Boron and additional doping by magnesium are expected to improve required luminescent properties. Selected sol-gel method determines the homogeneity of compounds and low temperatures of synthesis. Phosphor coatings were analyzed by X-ray diffraction analysis and scanning electron microscopies. Emission, excitation spectra and decay times have been investigated as well.

RESULTS

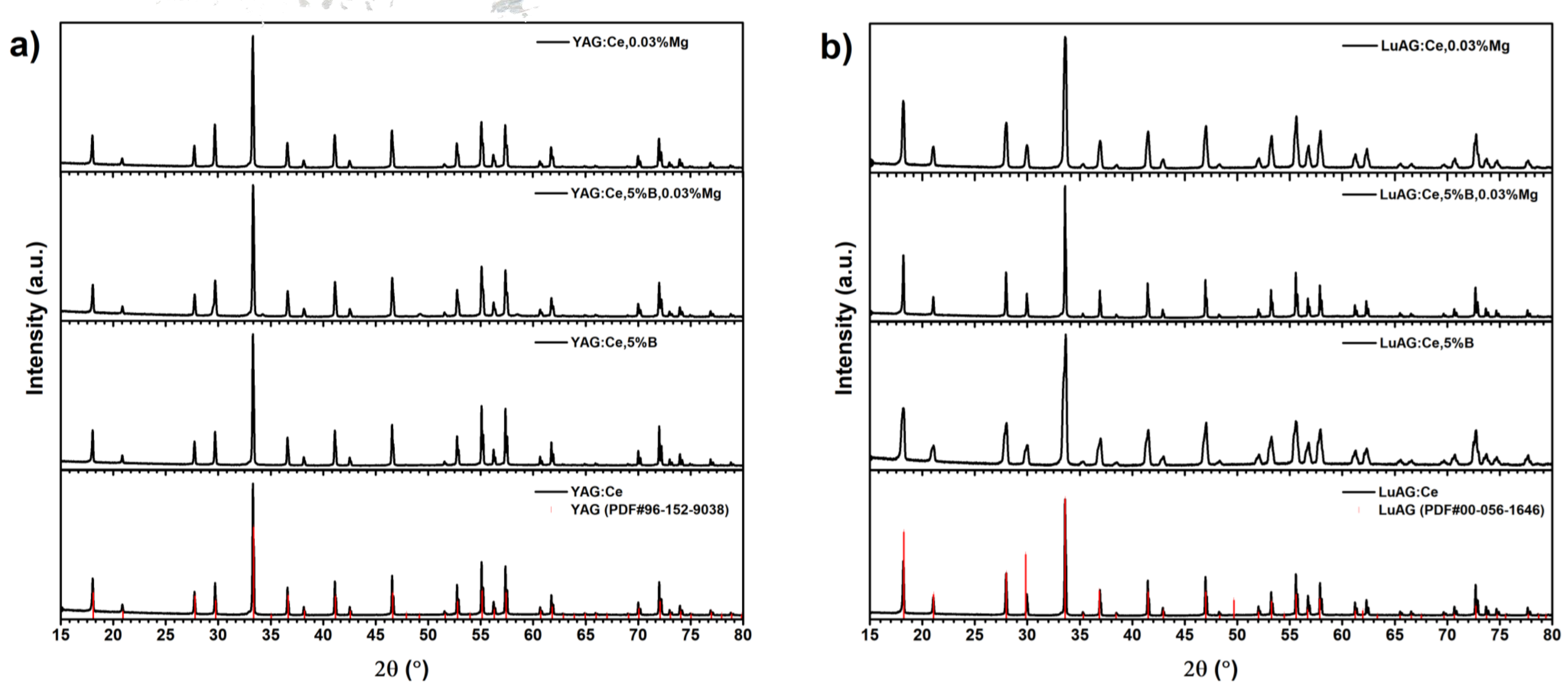

Fig. 1. Diffractograms of a) YAG and b) LuAG garnets ceramics.

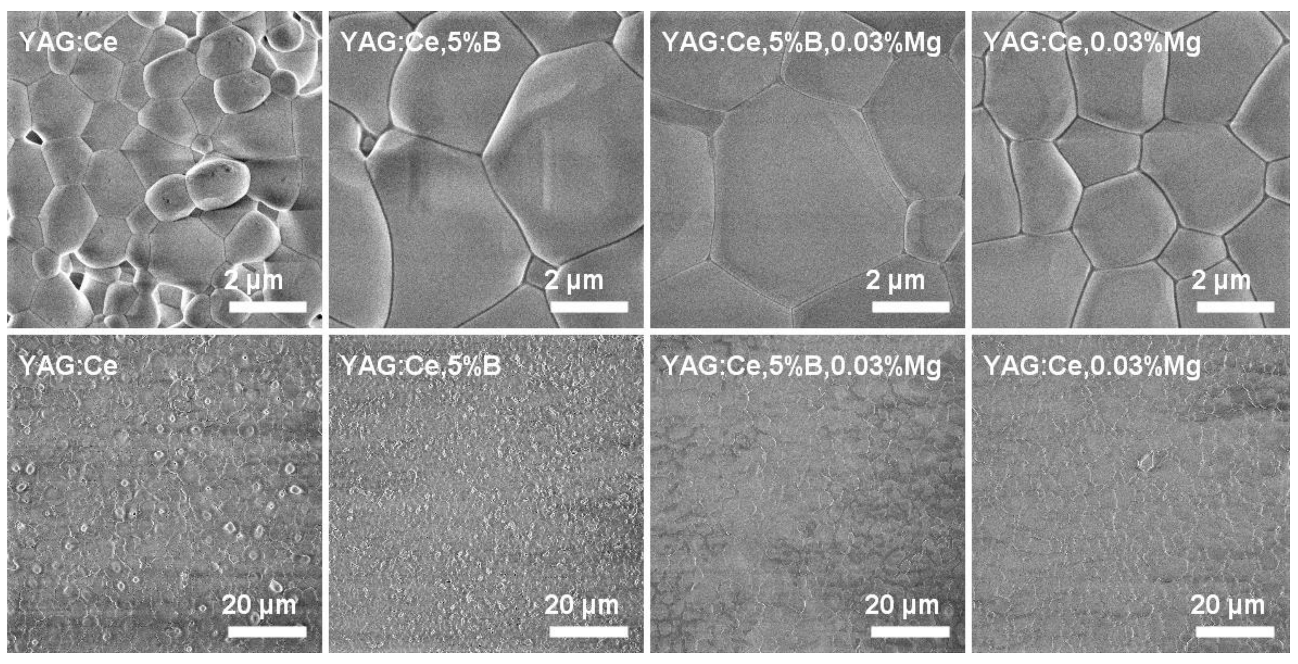

Fig. 2. SEM images of garnet ceramics.

1 Table. QE and decay time of YAG and LuAG ceramics.

Sample	QE, Quantum efficiency (%)	Decay time (ns)		
		τ_1	τ_2	τ_{Av}
YAG:Ce	29.79	18.59	58.48	55.79
YAG:Ce,5%B	20.57	16.04	56.44	52.74
YAG:Ce,5%B,0.03%Mg	37.54	18.41	67.84	66.51
YAG:Ce,0.03%Mg	38.93	21.44	60.06	60.16
LuAG:Ce	45.05	21.24	51.97	52.17
LuAG:Ce,5%B	28.51	21.32	52.68	48.86
LuAG:Ce,5%B,0.03%Mg	26.86	17.55	51.92	48.67
LuAG:Ce,0.03%Mg	44.34	32.24	57.47	54.86

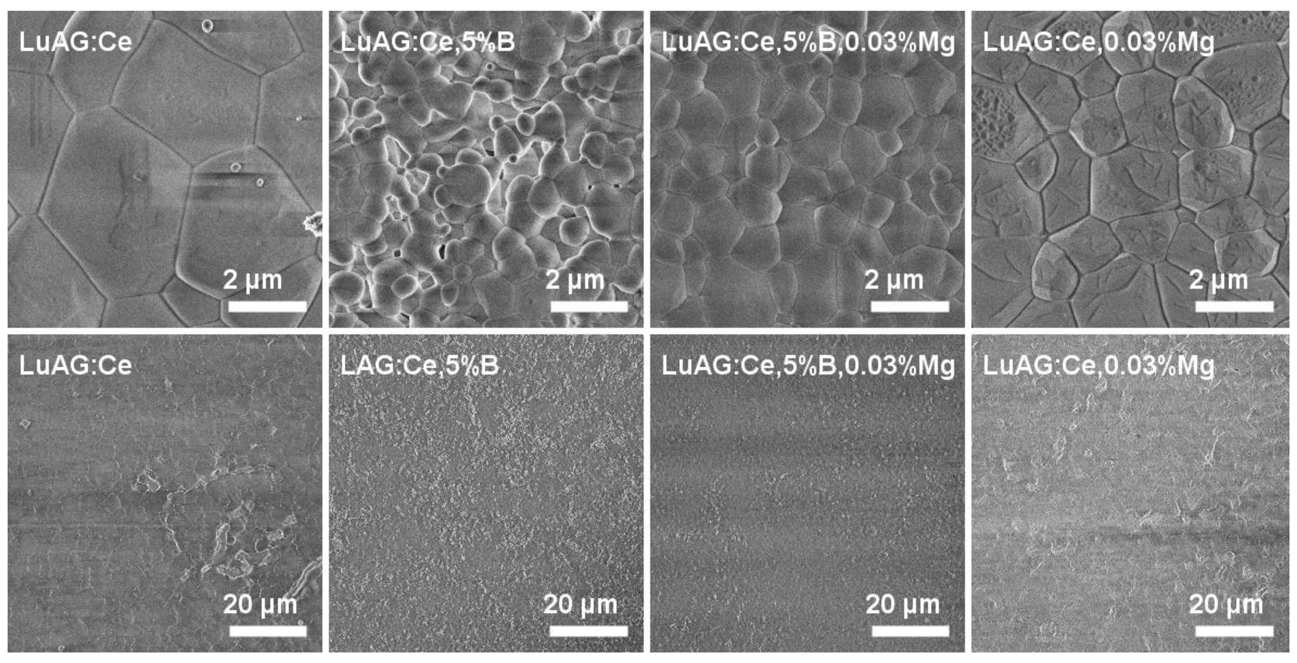

Fig. 3. SEM images of garnet ceramics.

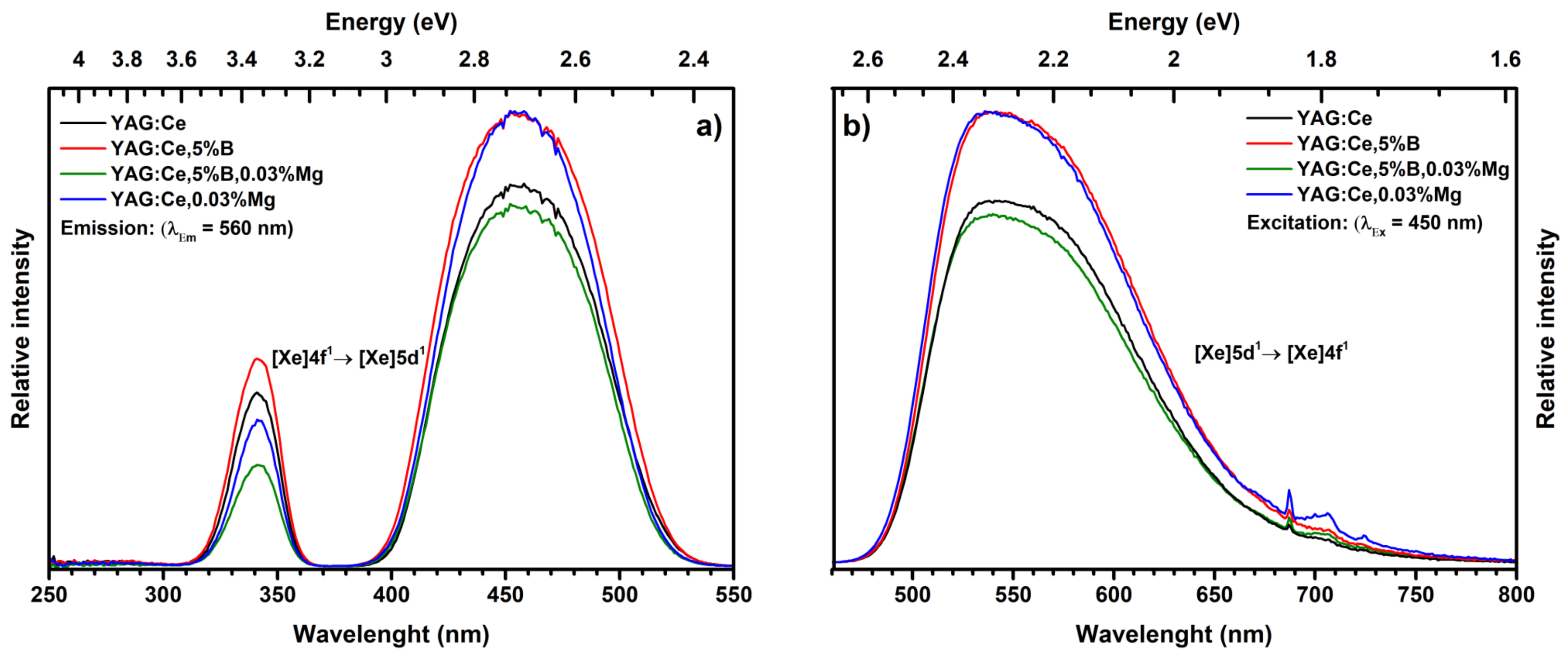

Fig. 4. a) Excitation and b) emission spectra of yttrium aluminum garnets.

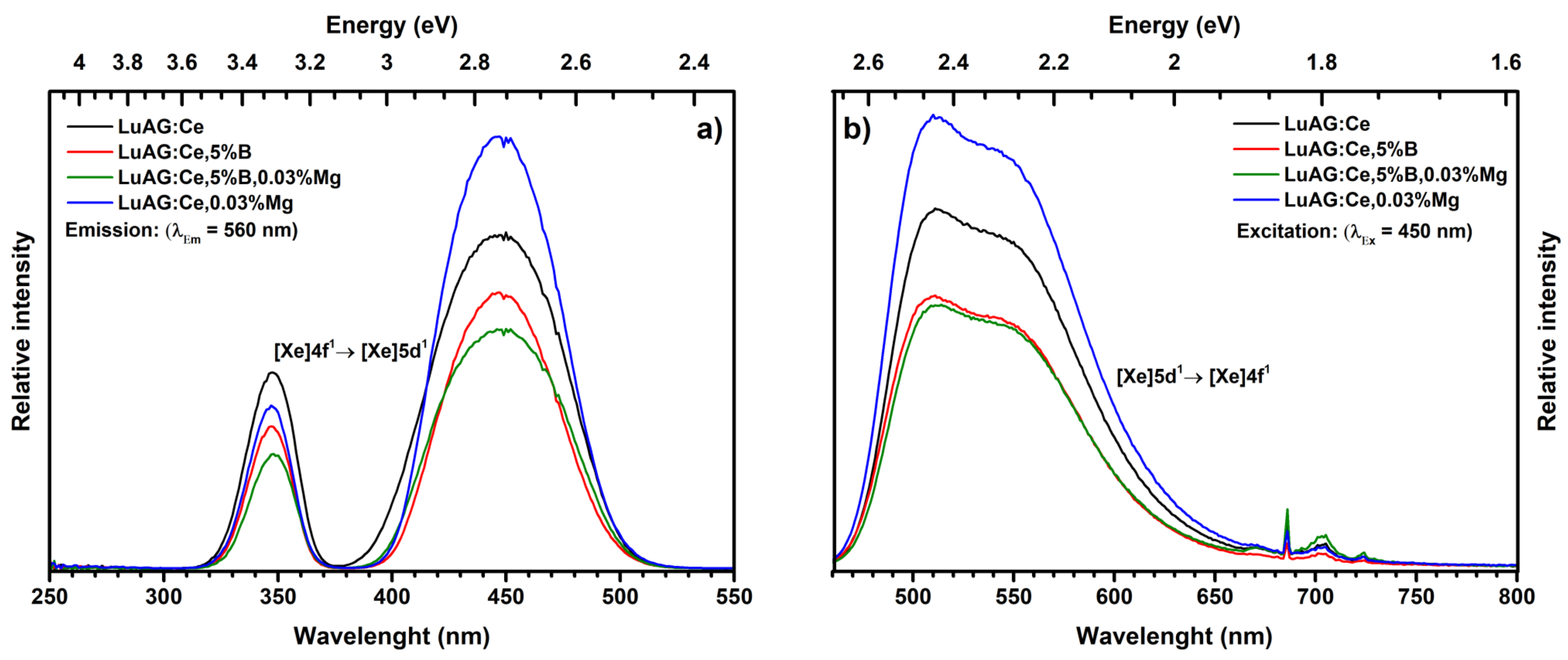

Fig. 5. a) Excitation and b) emission spectra of lutetium aluminum garnets.

CONCLUSIONS

- From XRD patterns it was determined that all ceramics heated for 4 hours at 1500 ℃ have a pure garnet phase.
- From SEM images it is observed that particles wary in sizes from 2 to 5 µm for all samples. However, an increase in size was also measured for compounds were doped boron and/or magnesium. It can also be seen that the LuAG:Ce,5%B sample has an overall unevenness in the ceramic surface, which arises from small pores.
- Magnesium doped YAG and LuAG samples have the most intense emission and excitation. However, all compounds show chromium impurities, indicated by the arising extra luminescence peaks.
- Samples containing boron have shorter decay time compared to pure garnet.

REFERENCES

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3. M.T. Lucchini, O. Buganov et al. J. Lumin. 194 (2018) 1-7.