ANNOMALOUS OPTICAL PROPERTIES OF YTTRIUM ALUMINUM GARNET DOPED WITH CHROMIUM

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Introduction

Yttrium aluminum garnet (YAG) with the nominal composition of $Y_3Al_5O_{12}$ is one of the most well-known oxide ceramics. Its lattice can act as a host for trivalent ions of which lanthanides are amongst the most common. Even though as by itself in recent times YAG has no substantial area of application this is changed after the addition of dopant ions. Being an optically isotropic material, it has seen huge success in research studies which were proceeded by making powders commercially viable. For example YAG:Nd, YAG:Er are being utilized as solid state lasers, optical phosphors of YAG:Ce were used in cathode ray tubes as luminescent material, as a phosphor in mercury vapor lamps or most commonly used nowadays – light emitting diodes for white light generation or scintillator materials [1-4]. Since single-crystal lasing material choices are quite limited mainly due to technological shortcomings such as the variation in melt temperature is one of the causes of inhomogeneous distribution of optically active ions, the surface of the melt also causes single-crystals to develop optical stress, striations in the end making them optically inhomogeneous. The breakthrough in ceramic lasers was achieved in 1995 with the advent of YAG:Nd polycrystalline ceramic laser, which showed equivalent or superior properties to single-crystal overcoming most of the technological shortcomings. Since then, the application of polycrystalline YAG has been widely studied as a viable substitute for single-crystals [2,5].

Work objective

The aim of this work was to synthesize different composition phosphors containing Cr^{3+} using classical sol-gel synthesis and characterize samples by XRD, ICP-OES and determine how luminescence intensity changes with concentration.

Experimental

In this work polycrystalline yttrium aluminum garnets doped with chromium were synthesized using classical sol-gel method. In short, nitrates of Al and Y and Cr were dissolved in a copious amount of deionized water to which nitric acid was added up until pH = 1. After thoroughly mixing materials, stoichiometric amount of ethylene glycol was added to keep it constant between samples. Resultant gel was dried for 24 hours and annealed at 1000 °C for 5 hours after which resultant powder was ground in agate mortar and analyzed using inductively coupled plasma optical emission spectrometry, x-ray diffractometry, scanning electron microscopy and photoluminescence measurements.

Results

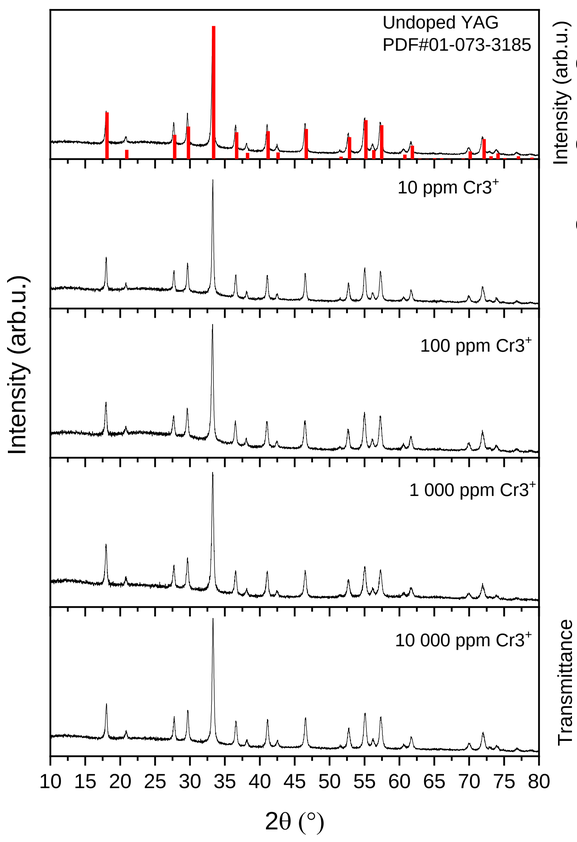

Fig 1. *X –ray powder diffraction patterns of doped and undoped samples*

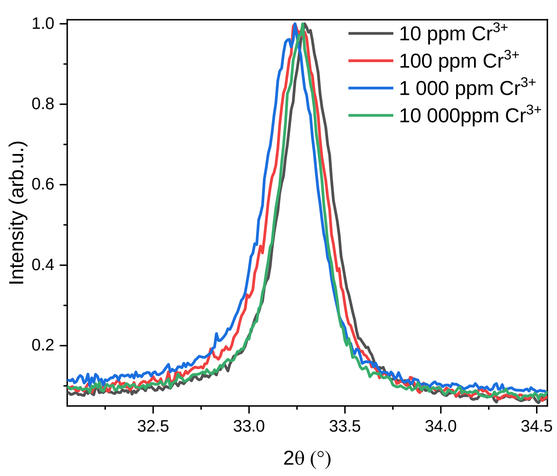

Fig 2. *X –ray powder diffraction peak shift with different dopant concentration*

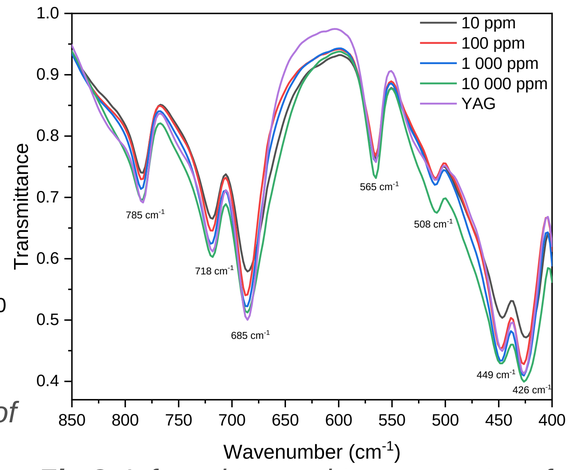

Fig 3. *Infrared transmittance spectra of garnet phase samples with different amount of Cr^{3+} acting as a doping agent*

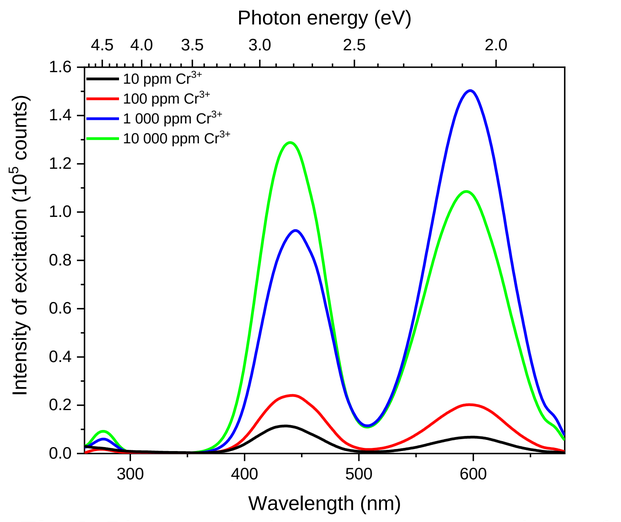

Fig 4. *Photoexcitation spectra comparison of different dopant level samples (λ_{em} = 706 nm)*

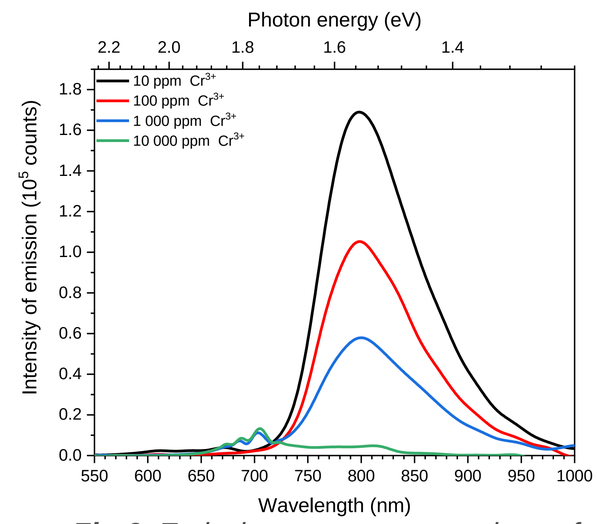

Fig 6. *Emission spectra comparison of different dopant level samples (λ_{ex} = 285 nm)*

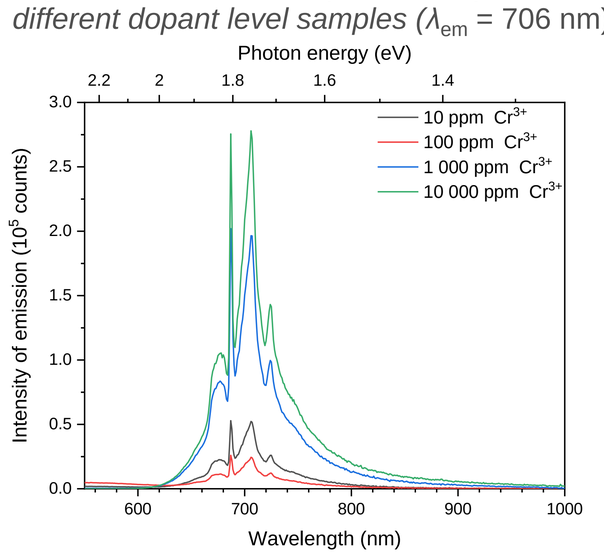

Fig 5. *Emission spectra comparison of different dopant level samples (λ_{ex} = 440 nm)*

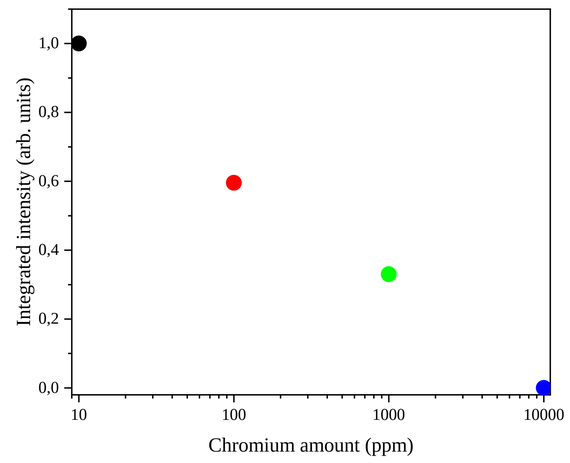

Fig 7. *Integral intensity of samples with different dopant levels (λ_{ex} = 285 nm)*

Conclusion

- In all of the samples with different dopant levels single garnet phase was formed.
- The amount of chromium by elemental analysis, using ICP-OES, is in good agreement with theoretical values as its variance does not exceed 5% of the base value.
- Near-infrared luminescence of the samples showed an increase in luminescence intensity with decreasing amount of chromium.

References

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