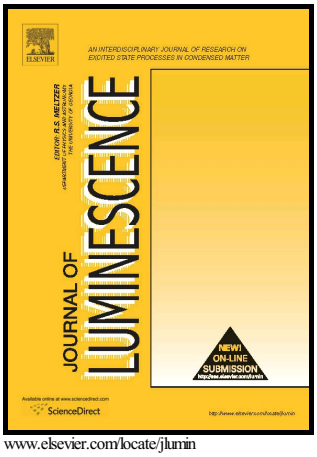
Co-occurrent white emission and photoconductivity in Yb^{3+} doped YAG nanoceramics induced by infrared laser excitation

M. Łukaszewicz, W. Stręk



www.elsevier.com/locate/jlumin

PII: S0022-2313(17)31968-3
DOI: https://doi.org/10.1016/j.jlumin.2018.03.063
Reference: LUMIN15482

To appear in: *Journal of Luminescence*

Received date: 17 November 2017
Revised date: 12 February 2018
Accepted date: 21 March 2018

Cite this article as: M. Łukaszewicz and W. Stręk, Co-occurrent white emission and photoconductivity in Yb^{3+} doped YAG nanoceramics induced by infrared laser excitation, *Journal of Luminescence,* https://doi.org/10.1016/j.jlumin.2018.03.063

Co-occurrent white emission and photoconductivity in Yb^{3+} doped YAG nanoceramics induced by infrared laser excitation

M. Łukaszewicz*, W. Stręk

Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Department of Spectroscopy of Excited States, Okólna 2, Wrocław, Poland, 50-422

Abstract. Photoconductivity and laser induced white emission were investigated in Yb^{3+} doped YAG nanoceramics under infrared laser excitation in vacuum. Correlation between the two phenomena was analyzed. Power dependences of both photocurrent and white emission exhibited a threshold behavior characteristic for multiphoton avalanche processes. Comparison between different dopant concentrations showed that with higher Yb^{3+} content, the magnitudes of broadband emission intensity and photoconductivity rise. Furthermore, the excitation power thresholds for occurrence of the said phenomena decrease with increasing dopant concentration.

Keywords: photoconductivity, white light emission

* Mikołaj Łukaszewicz, E-mail: m.lukaszewicz@int.pan.wroc.pl

1. Introduction

Yttrium aluminum garnet (YAG) doped with rare earth ions is commonly used as a photoluminescent medium in numerous applications, such as solid-state lasers, phosphors in cathode ray tubes, light emitting diodes or scintillators [1-4]. Monocrystalline YAG doped with ytterbium is used as an active laser medium emitting at 1030 nm [5]. Recently, Yb-doped YAG has also been studied in micro- and nanocrystalline form, either as a powder or a sintered ceramic [6-10]. Broadband anti-Stokes white light emission has been observed under infrared laser excitation in Yb-doped YAG materials [11, 12] as well as in other lanthanide based phosphors [13-15]. As the energy level structure of Yb ions in the YAG matrix is very modest [16], numerous models have been proposed recently for white light generation in lanthanide-based systems, including the intervalence charge transfer (IVCT) [17], multiphoton absorption [18], photon avalanche [19] simultaneous de-excitation of a two or more dopant ions and other up-conversion mechanisms [20].

Photocurrent induced by optical excitation of phosphor materials is investigated as either a parasitic process in laser materials [21], fundamental phenomenon for design of optoelectronic devices [22] or as a means of validating hypotheses established for other observed spectroscopic phenomena, such as the mechanism of excitation leading to observed photoluminescence [23]. Photoconductivity in nanocrystalline dielectric phosphors has been reported earlier by our group for strontium cerium oxide, pure and doped with Eu^{3+} and Nd^{3+} [24-26]. Photocurrent has been investigated in YAG: Yb^{3+} single crystal by Brandt et al. [27]. Even though the yttrium aluminum garnet doped with rare earth ions is a highly popular subject of investigation in optical and optoelectronic sciences, there are still only a few sources on photoconductivity measured in this group of materials, with data especially scarce on the topic of micro- and nanoceramics.

In the present work, white emission and photoconductivity induced by infrared laser excitation are investigated in YAG nanoceramics doped with Yb^{3+}. Influence of dopant concentration on photocurrent and emission intensity is analyzed, as well as its impact on optical power threshold required for the aforementioned phenomena to be observed. Similarities and differences between the two processes are discussed.

2. Materials and methods

Nanocrystalline YAG: Yb^{3+} powder was produced using the modified Pechini method, as described earlier in a paper by Hreniak et al. [9]. Powders were prepared with various Yb^{3+} concentration: 2%, 5%, 10%, 50% and 100% (YbAG). The average grain size of the crystalline powder was 30-40 nm. They were subsequently compressed into nanoceramics using the low temperature high pressure (LTHP) sintering method (see Fig. 1a) [10]. The resulting structure is composed of crystalline grains maintaining their nanoscale dimensions