Photo- and upconversion luminescence of phosphores activated with rare earth elements

Grigory Arzumanyan
Deaprtment of Raman Spectroscopy, Frank Laboratory of Neutron Physics

Introduction

The development of modern high technologies, including nanotechnologies opens great prospects for the development of new nanostructured composite materials with the widest range of applications. In optics, one of such technologies is based on the spectral conversion of radiation, in particular, on effect of the up-conversion luminescence (UCL) in nanostructured matrixes. This effect, representing a kind of the anti-Stokes radiation, can be effectively used in the producing of materials for photovoltaic systems, short wavelength lasers, various optoelectronic devices, biophosphors, etc.

Currently, much attention is paid to the searching and investigating of materials that will increase the effectiveness of UCL processes. Oxyfluoride vitroceramics activated with rare-earth elements (REE), such as erbium, europium, thulium, yttrium, ytterbium, etc., are the most promising materials. The matrixes received on basis of oxyfluride glass ceramics represent a good alternative to chalcogenide and halide materials, the synthesis of which is complex and expensive due to the need to prevent the interaction of it with the circumambient in the process of synthesis.

REE ion are very attractive materials as a phosphors due to its ability to luminesce in a wide wavelength range, saturated and optimal for UCL energy structure, as well as the existence of metastable energy states. It should be noted the versatility of their use, In a type of that the electrons on *4f*-shell are screened by external *5p2*-and *5p6*-shells, resulting that the position of energy states, characterized by the spin-orbit interaction, very poorly depends on circumambient and remains almost constant for the same ion that allows to use REE in the most various matrixes.

Experimental: Laser-scanning CARS microscope

The multimodal optical platform (CARS microscope) for performing photo- and upconversion luminescence as well as Raman scattering is shown in Fig.1.

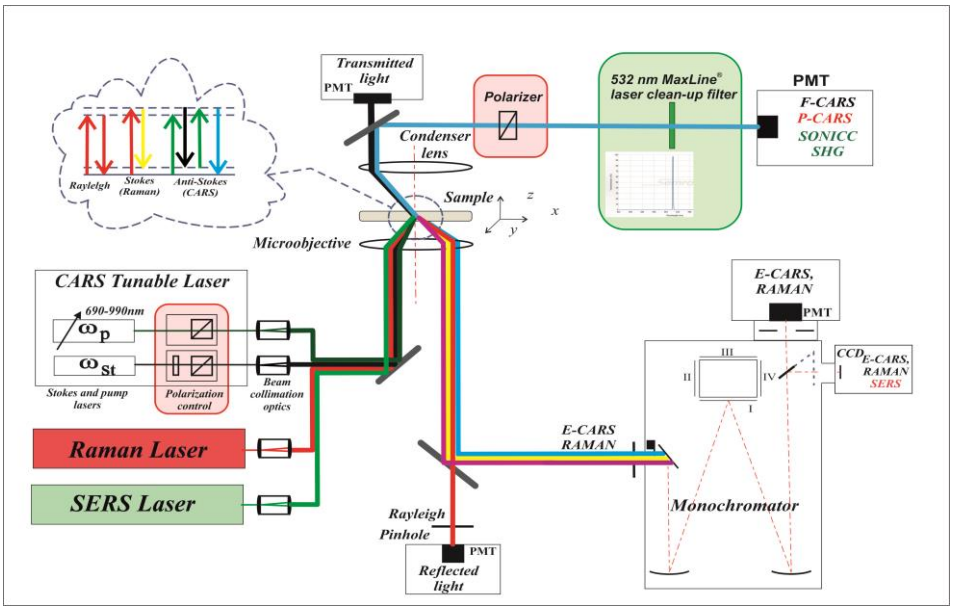

Fig. 1 The layout of the multimodal optical platform: “CARS” microscope

In the given optical platform a diod-pump Nd:YVO4 picosecond laser is used as a source of the Stokes wave; it has the wave length of 1064 nm, pulse duration of 7 ps and output power of 5W at the pulse repetition rate of 85 MHz. Only a small portion of radiation was directed to the microscope, the main part of radiation was used for the second harmonic intracavity generation to be applied for the synchronous pumping of the optical parametric oscillator (SOPO). That provided generation of picosecond pulses tunable from 690 nm to 990 nm, with pulse duration of 6 ps and output power up to 0.3W at the repetition rate of 85 MHz.
The microscope is also equipped with a system of collimators, dichroic mirrors and filters whose installment and change is done automatically on PC commands. The microscope is equipped with 6 independent registration channels, two in the forward direction and four in the backward direction.

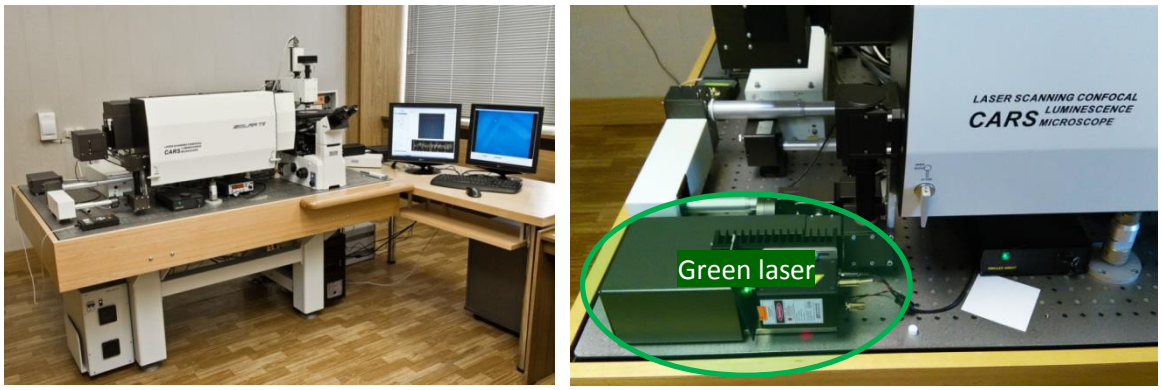

Fig.2 General view of the CARS microscope

For the photo- and upconversion luminescence studies a diode green laser (532nm) and near infrared laser radiation from SOPO are utilized (Fig.2).

The measurement procedure

The potential participant (student) will be acquainted with the whole circle of the measurement procedure consisting of: preliminary spectra calibration, laser line alignment, choice of the optical filters and microobjective, scan of the samples and detecting of the luminescence spectra. An example of photo- and upconversion emission spectra is demonstrated in Fig.3.

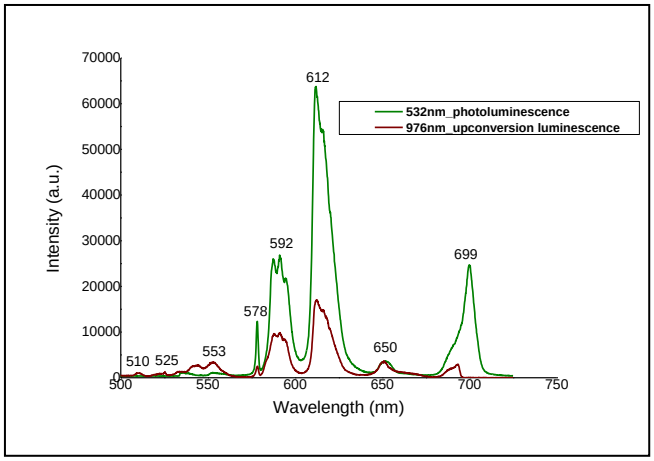

Fig.3 Photo- and upconversion luminescence spectra of oxyfluoride glass co-doped with Eu^{3+} and Yb^{3+} ions

Presentation of results

The results are supposed to be presented in the text format including introduction, obtained results, their description and discussion, as well as (desirable) in Power point format. The knowledge of ORIGIN and Power Point software packages for data processing and presentation is obligatory.

Proposed literature

Jiao Chen and Julia Xiaojun Zhao, "Upconversion Nanomaterials: Synthesis, Mechanism, and Applications in Sensing", Sensors 2012, 12, 2414-2435; doi:10.3390/s120302414

F. Auzel, "Upconversion and Anti-Stokes Processes with f and d Ions in Solids", Chem. Rev. 2004, 104, 139-173

Y. Dwivedi and S.C. Zilio, "Infrared cascade and cooperative multicolor upconversion emissions in Y8V2O17:Eu:Yb Nanophosphors", OPTICS EXPRESS, 2013, Vol. 21, No. 4

Number of students: 1

The project supervisor

Dr Grigory Arzumanyan
Head of the Department of Raman Spectroscopy, Frank Laboratory of Neutron Physics, JINR.