Fluorescence Studies on rare Earth Ions in close Vicinity to metallic Nanoparticles

Application Note

S. Wackerow, G. Seifert, University Halle-Wittenberg (September 2009)

Introduction

Rare earth ions implanted in glasses are a current topic encountering growing interest in the scientific community because of their wide potential for photon management in context with, e.g., photovoltaic energy conversion. Researchers are in particular interested in up- and down conversion of photons below or far above the band gap of semiconductor-based solar cells in order to optimize their efficiency. The radiative properties of these ions are on the one hand strongly depending on the phonon frequencies of the glass they are included in. It has been shown recently that, in addition, metallic nanoparticles in close vicinity to such rare earth ions can strongly enhance their absorption and / or emission cross sections [1]. In our group we are currently investigating different approaches to co-dope various glass samples with Ag nanoparticles and rare earth ions such as Nd^{3+} in order to find a material where the luminescence of the ions is modified by the neighboring silver clusters. If for instance the photoluminescence is decreased due to a longer lifetime of the respective electronic state, the probability for up-conversion by absorbing a second photon would increase. Therefore we need a sensitive and reliable detection system for the near infrared range.

Experimental setup and examples for spectra

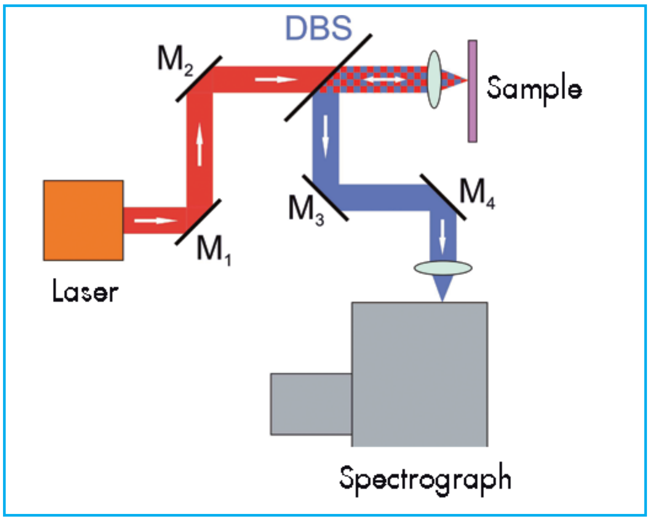

Fig.1: (a) Schematic setup for fluorescence detection; M_1 ... M_4 Mirrors; DBS: dichroic beam splitter.

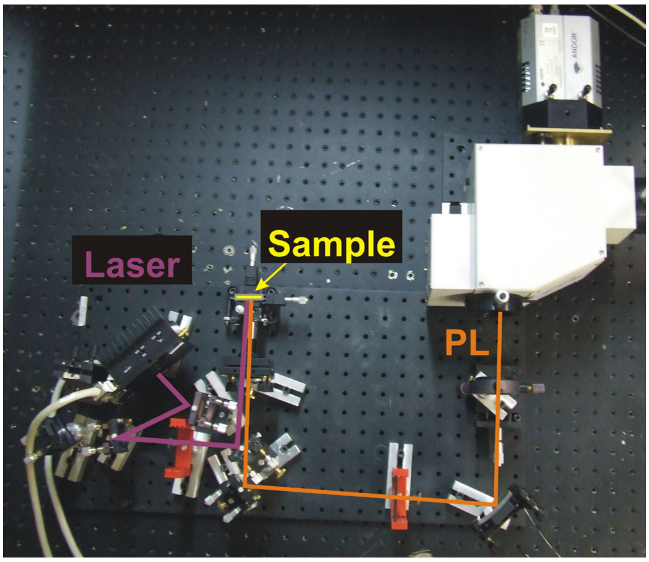

Fig.1: (b) photograph of real setup.

Figure 1 shows a schematic sketch and a real photo of our setup. Light from the exciting laser (diode laser at 803nm) passes a dichroic beam splitter, which is transparent for the laser wavelength, but highly reflective for the expected photoluminescence. In that way the light being emitted backward from the sample can be measured separately by an InGaAs photodiode array (InGaAs iDus DU490A-1.7 from Andor Technology) behind a spectrograph (MicroHR from Jobin-Yvon).

S. Wackerow, G. Seifert, University Halle-Wittenberg (September 2009)

The mirrors allow us the necessary fine-adjustment to get maximum signal into the detection system.

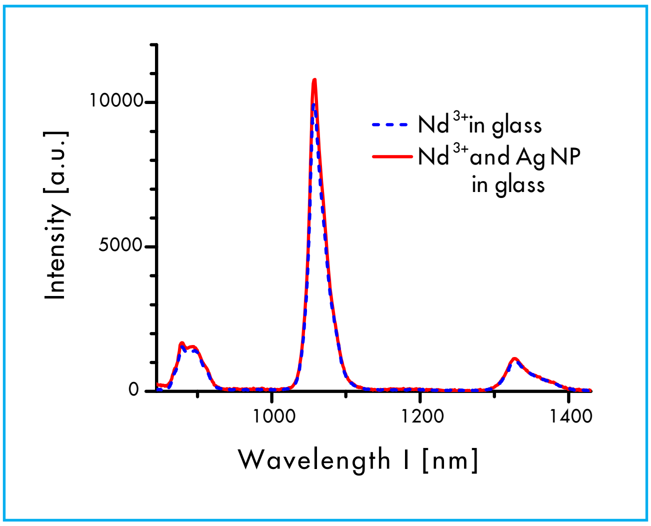

Fig.2:Photoluminescence spectra obtained on glass samples containing Nd^{3+} ions (red curve) or Nd^{3+} ions plus Ag nanoparticles (blue, dashed curve).

As an example Fig. 2 shows photoluminescence observed from a glass containing approximately 2% Nd^{3+} ions, one part of the sample was additionally co-doped with Ag nanoparticles [2]. Though these preliminary data do not yet prove an effect from the NPs, it is obvious that the quality of the spectra makes it possible to detect very small changes of the PL properties.

References

[1] H. Mertens, A. Polman, *Appl. Phys. Lett.* 89, 211107 (2006)

[2] F. Hallermann, C. Rockstuhl, S. Fahr, G. Seifert, S. Wackerow, H. Graener, G. v. Plessen, F. Lederer, *phys. stat. sol (a)* **205**, 2844 (2008)

Contact

S. Wackerow, Dr. G. Seifert
Optics Group
Institute of Physics
Martin-Luther-University Halle-Wittenberg

Phone: +49 (345) 552 5314
Mail: stefan.wackerow@physik.uni-halle.de
Web: www.physik.uni-halle.de/Fachgruppen/optik