Photoluminescence quantum yield as a test of quantum cutting processes in down-converting phosphors

Ya. Zhydachevskyy1,2, V. Tsiumra1, M. Baran3, L. Lipińska3, I.I. Syvorotka4, A. Wierzbicka1 and A. Suchocki1,5

1Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

2Lviv Polytechnic National University, Lviv, Ukraine

3 Institute of Electronic Materials Technology, Warsaw, Poland

4 Scientific Research Company “Carat”, Lviv, Ukraine

5 Institute of Physics, University of Bydgoszcz, Bydgoszcz, Poland

e-mail: [zhydach@ifpan.edu.pl](mailto:zhydach@ifpan.edu.pl)

Ionic-like down-converting phosphors nowadays are actively discussed for solar spectrum modification and in such a way for possible enhancement of the efficiency of silicon solar cells. Phosphors co‑doped with Ce3+−Yb3+, Eu2+−Yb3+ or Bi3+−Yb3+ ions are of particular interest because of the efficient and broad absorption in UV-blue range and the near-IR emission around 1 μm from Yb3+. However the real value of the energy transfer efficiency in such materials remains generally unknown. In other words, the question remains whether the energy transfer is cooperative (one-to-two) or non-cooperative (one-to-one energy transfer). This efficiency is usually estimated from shortening of the luminescence decay of donor (Ce3+, Eu2+ or Bi3+) ion, when the conversion ratio of 2.0 (*i.e.* an ideal quantum cutting mechanism) is postulated.

Instead of this we propose a direct measurement of quantum yield (QY), which allows to estimate a real value of the conversion ratio. This procedure was already tested by us for such phosphors as Y4Al2O9 (YAM):Bi,Yb; Gd2O3:Bi,Yb; YVO4:Bi,Yb; YNbO4:Bi,Yb; Y3Al5O12 (YAG):Bi,Yb; Gd3Ga5O12 (GGG):Bi,Yb and YAG:Ce,Yb. Results for these materials will be presented and discussed. Our results testify that not all the phosphors that demonstrate the energy transfer from Ce3+ or Bi3+ to Yb3+ have the cooperative energy transfer. The procedure used in this study can be also applied to other systems proposed for quantum cutting in order to evaluate their performance for solar spectrum modification.

*Acknowledgements:* The work was supported by the Polish National Science Center (project 2015/17/B/ST5/01658) and by the EU within the European Regional Development Fund through the Innovative Economy grant (POIG.01.01.02‑00-108/09).