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Photoluminescent Properties of Noble Metal Nanoparticles Supported Yttrium Aluminum Garnet Nanoparticles Doped with Cerium (Ⅲ) Ions

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Abstract : Yttrium aluminum garnet doped with cerium (Ⅲ) ions (Y3Al5O12:Ce3+, YAG:Ce3+) has attracted a great attention because it can efficiently convert the blue light into a very broad yellow emission band, which produces white light emitting diodes and is applied for panel displays. To improve the brightness and resolution of the display, a considerable attention has been directed to develop fine phosphor particles. We have prepared YAG:Ce3+ nanophosphors by environmental-friendly wet process. The peak maximum of absorption spectra of surface plasmon of Ag nanopaticles are close to that of the excitation spectra (460 nm) of YAG:Ce3+. It can be expected that Ag nanoparticles supported onto the surface of YAG:Ce3+ (Ag-YAG:Ce3+) enhance the absorption of Ce3+ ions. In this study, we have prepared Ag-YAG:Ce3+ nanophosphors and investigated their photoluminescent properties. YCl3□6H2O and AlCl3□6H2O with a molar ratio of Y:Al=3:5 were dissolved in ethanol (100 ml), and CeCl3•7H2O (0.3 mol%) was further added to the above solution. Then, NaOH (4.6×10-2 mol) dissolved in ethanol (50 ml) was added dropwise to the mixture under reflux over 2 hours, and the solution was further refluxed for 1 hour. After cooling to room temperature, precipitates in the reaction mixture were heated at 673 K for 1 hour. After the calcination, the particles were immersed in AgNO3 solution for 1 hour, followed by sintering at 1123 K for 1 hour. YAG:Ce3+ were confirmed to be nanocrystals with a crystallite size of 50-80 nm in diameter. Ag nanoparticles supported onto YAG:Ce3+ were single nanometers in diameter. The excitation and emission spectra were 454 nm and 539 nm at a maximum wavelength, respectively. The emission intensity was maximum for Ag-YAG:Ce3+ immersed into 0.5 mM AgCl (Ag-YAG:Ce (0.5 mM)). The absorption maximum (461 nm) was increased for Ag-YAG:Ce3+ in comparison with that for YAG:Ce3+, indicating that the absorption was enhanced by the addition of Ag. The external and internal quantum efficiencies became 11.2 % and 36.9 % for Ag-YAG:Ce (0.5 mM), respectively. The emission intensity and absorption maximum of Ag-YAG:Ce (0.5 mM)×n (n=1, 2, 3) were increased with an increase of the number of supporting times (n), respectively. The external and internal quantum efficiencies were increased for the increase of n, respectively. The external quantum efficiency of Ag-YAG:Ce (0.5 mM) (n=3) became twice as large as that of YAG:Ce. In conclusion, Ag nanoparticles supported onto YAG:Ce3+ increased absorption and quantum efficiency. Therefore, the support of Ag nanoparticles enhanced the photoluminescent properties of YAG:Ce3+.

Keywords : plasmon, quantum efficiency, silver nanoparticles, yttrium aluminum garnet
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