Luminescence properties of YVO$_4$:Eu$^{3+}$ nanocrystals in VUV spectral range

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Europium doped yttrium vanadate is one of the most important phosphor materials which currently find a variety of applications in cathode ray tubes [1], fluorescent lamps [2] and scintillator in image detectors [3]. Also YVO$_4$:Eu is promising material for high definition TVs based on plasma display panels [4]. YVO$_4$:Eu is characterized by its high energy-conversion efficiency, brightness, color purity, and high thermal stability. YVO$_4$:Eu the advantage over the currently used sulfide phosphors in stability in vacuum and absence of corrosive gas emission under electron bombardment. As a nanomaterial, YVO$_4$:Eu is relevant for these issues as well [5]. Additional interest is related to labeling, signaling, and biomedical purpose.

In present work comparative analysis of the luminescent properties of nanocrystalline YVO$_4$:Eu luminescent materials with macro crystalline analogues, commercially produced by Philips, has been performed. Nanocrystalline YVO$_4$:Eu (particle size is 12-15 nm, Eu$^{3+}$ ions concentration is 15 mol%) was produced by means of a microwave-induced synthesis in ionic liquids, which allows the efficient particle size, quality and impurity level control [6]. In order to avoid luminescence degradation due to surface loses YVO$_4$:Eu nanocrystals has been covered by YF$_3$ layer with thickness 1-2 nm (YVO$_4$:Eu@YF$_3$). The luminescence emission and excitation measurements were carried out under pulsed synchrotron radiation emitted from DORIS III storage ring on the SUPERLUMI station at HASYLAB.

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![Fig. 1. Comparison of luminescence spectra in YVO$_4$:Eu in wide spectral range under 280 nm.](image1)

![Fig. 2. Comparison of fine structure of Eu$^{3+}$ emission in YVO$_4$:Eu under 300 nm excitation.](image2)

Luminescence spectra at 8 K for all samples are shown on the figure 1. Spectra is normalized at 617.5 nm. Spectra consist of characteristic Eu$^{3+}$ line and wide VO$_4^{3-}$ molecular complex intrinsic emission band. Is clearly seen that this intrinsic emission is absent in YVO$_4$:Eu nanocrystals covered by YF$_3$ layer.

Well-resolved characteristics Eu$^{3+}$ emission lines due to $^5D_0-^7F_J$ transitions have been observed in all samples studied (figure 2). The energy transfer mechanism of VO$_4^{3-}$—Eu$^{3+}$ is well-known to occur after a thermally activated energy migration through the vanadate sublattice. The emission of YVO$_4$:Eu nanoparticles usually occurs after energy transfer from the excited vanadate to the
europium ions [7]. It is shown, that Eu$^{3+}$ luminescence intensity is drastically decreased in nanocrystals comparing with the bulk sample. However, this emission could be partially restored in nanocrystals with passivated surface (YVO$_4$:Eu@YF$_3$). Obviously surface related loses are suppressed in covered nanocrystals.

Excitation spectra of europium emission in YVO$_4$:Eu is shown on figure 3. Spectra contain abundant structure at low energies and several broad overlapped intensive excitation bands at high energies. The short-wavelength excitation at around 260 nm is due to charge-transfer processes involving the Y–O components [8]. Comparing the nano and macrocrystalline samples is clearly seen, that Eu$^{3+}$ emission is poorly excited in nanocrystalline samples at energies, when the spatial separation of electron-hole pairs is comparable with sizes of nanoparticles. We suggest that energy-transfer processes form YVO$_4$ matrix to Eu$^{3+}$ ions are suppressed in nanocrystals, due to some competing relaxation channels, which are absent in bulk material.

On the other hand, excitation spectra of VO$_4^{3-}$ complex emission in YVO$_4$:Eu (figure 4) doesn’t differ so much for macro and nano crystals. It seems, the particle size doesn’t influence significantly the intrinsic emission centers in YVO$_4$:Eu.

**References**


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