Impurity luminescence of the opal-ZnO nanocomposite

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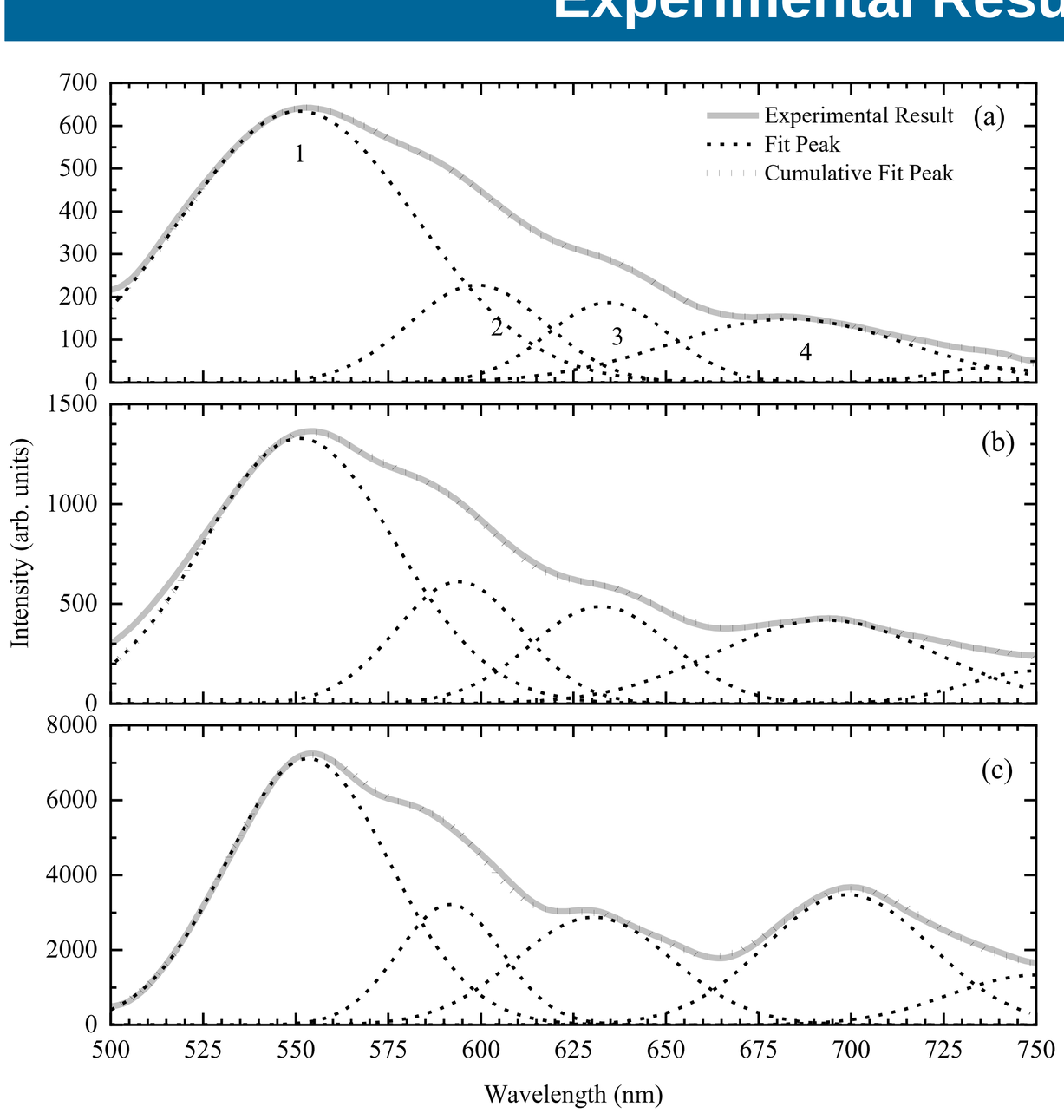
Annotation

This work is devoted to the study of the impurity photoluminescence spectra of synthetic opals infiltrated with zinc oxide. The photoluminescence spectra of ZnO in the opal pores in the [111] direction have been measured and the parameters of the spectral components of the observed luminescence band have been determined with different cycles of infiltration. It was found that the luminescence has an impurity character and is due to the presence of impurities Cu^{2+}, Li^{+}, Na^{+}, and Fe^{3+}.

Samples and experimental technique

Bulk synthetic opals were grown by slow crystallization of monodisperse colloidal suspension of globules α-SiO_2 synthesized by modified Stober method. The hydrolysis of tetraethoxysilane was carried out in an aqueous-alcoholic medium in the presence of ammonia as a catalyst. Synthetic opals were obtained by the method of natural sedimentation under isothermal conditions at T = 20°C. The initial opals (the position of the stop-band 483-537nm) were impregnated with an aqueous solution of zinc nitrate $Zn(NO_3)_2$ n H_2O, followed by the release of zinc oxide in the pores during heat treatment in air [1, 2]. Zinc nitrate after heating up to 650°C decomposes to zinc oxide, nitrogen oxide and oxygen : $2Zn(NO_3)_2 \rightarrow 2ZnO + 4NO_2\uparrow + O_2$.

Experimental Results and Discussions



The figure on the left shows the photoluminescence spectra of opal-ZnO composites after 1 impregnation cycle (a), 2 cycles (b), and 3 cycles (c). The dash-dotted lines show the spectral components.

The photoluminescence spectra of opal-ZnO nanocomposites were measured upon excitation by an LED with λ_{ex}=407 nm. Luminescence was recorded in the [111] direction. A wide structured band was observed in the region of 500-750 nm. In addition, near the edge of intrinsic absorption, three luminescence bands are observed in the visible spectral region due to impurities Cu^{2+}, Li^{+}, Na^{+}, and Fe^{3+} [3]. The parameters of 4 elementary spectral components at various levels of infiltration are determined. An increase in the integrated intensity of all bands by 8 times with 3 cycles of impregnation was observed. The band in the region of 525-575 nm was most intense. The amplification in this case is due to the coincidence of the spectral position of the band maximum with the long-wavelength edge of the opal stop-band, where the maximum density of optical states takes place. In addition, the previously observed effect of pushing out the luminescence band from the stop-band was manifested. Taking into account the latter, the nature of this band can be associated with radiative transitions in Cu^{2+} impurity ions replacing Zn atoms [3].

References

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