ISSN 1063-7826, Semiconductors, 2018, Vol. 52, No. 16, pp. 2054–2056. © Pleiades Publishing, Ltd., 2018.

26th INTERNATIONAL SYMPOSIUM "NANOSTRUCTURES: PHYSICS AND TECHNOLOGY".
NANOSTRUCTURE CHARACTERIZATION

Polarization Properties of Photoluminescence of Anisotropic Polymer Films Containing Aligned Au Nanorods and Semiconductor Nanoparticles of Various Shape[1]

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Abstract—Anisotropic polymer films containing aligned Au nanorods and semiconductor nanoparticles of various shape were fabricated. The photoluminescence of semiconductor nanoparticles in these films is partially polarized. The value of the photoluminescence polarization degree of quantum dots embedded in an anisotropic PVA-film after 4.5-fold stretching $P = 0.27$ has been obtained.

DOI: 10.1134/S1063782618160108

1. INTRODUCTION

Development of affordable approaches and techniques for fabrication of anisotropic light emitting materials is important for many applications, first of all as backlight sources in LCD devices. Semiconductor quantum dots have been already involved in the design of modern LCD TV-sets and monitors and are generally considered as potential substitute for rare-earth phosphors and as principal component in emerging colloidal optoelectronics [1–3]. Plasmonic enhancement of quantum dot luminescence is extensively studied during more than a decade [4]. Quantum dots in presence of aligned metal nanorod are expected to exhibit polarized emission owing to anisotropic enhancement effect both with respect to excitation and with respect to emission. Nanoplatelets are

[1] The article is published in the original.

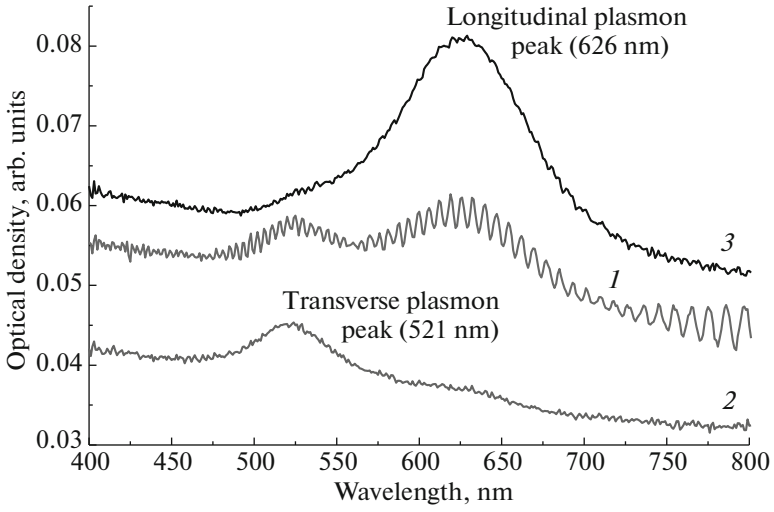

Fig. 1. Optical density spectra of stretched PVA-films with embedded Au-nanorods in linear polarized light: *1*—initial non-stretched PVA-film, *2*—the direction of electric field strength component of incident light wave and the direction of film stretching are perpendicular, *3*—the direction of electric component of light and the direction of stretching are parallel.

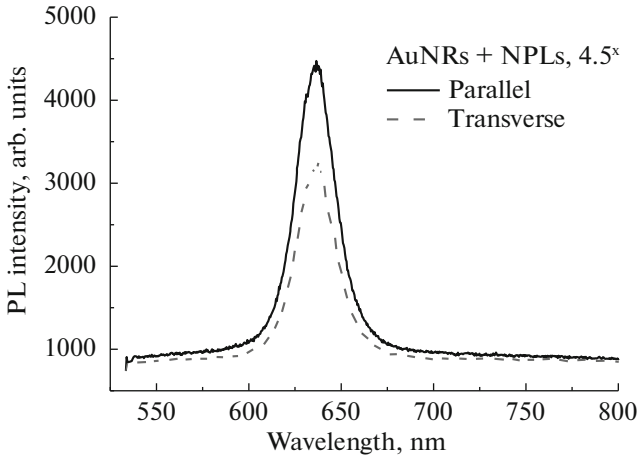

Fig. 2. Photoluminescence spectra of stretched PVA-film containing aligned Au nanorods and CdSe/CdS nanoplatelets in parallel and transverse polarization with respect to the alignment (film stretching) direction.

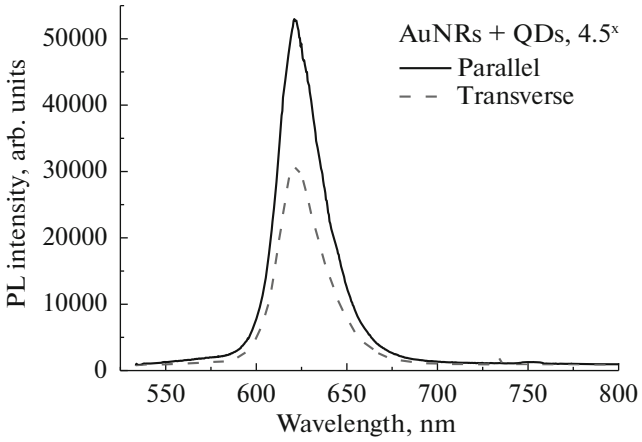

Fig. 3. Photoluminescence spectra of stretched PVA-films containing CdSe/CdZnS quantum dots and Au nanorods in parallel and transverse polarization with respect to the alignment (film stretching) direction.

the colloidal analog to epitaxial quantum well structures with manifold enhancement of exciton binding energy [5]. In this work, we report on experimental technique for making luminescent film with aligned metal nanorods and luminescent semiconductor quantum dots and nanoplatelets.

Several groups suggested approach to alignment of metal nanorods in polymers [6–11] but alignment effect on polarization of photoluminescent species therein has not been reported.

2. EXPERIMENTAL

Anisotropic polymer films containing elongated metal nanoparticles and semiconductor nanocrystals of various shapes were produced from 5% solution of polyvinylalcohol in water. Gold nanorods were synthesized according to the procedure [12].

Two types of anisotropic films were made: the film with electrostatic nanocomplexes of Au nanorods and CdSe/CdS nanoplatelets, and the film with nanocomplexes of Au nanorods and CdSe/CdZnS quantum dots.

The initial isotropic PVA-films of thickness about 40 μm were stretched by the factor of 4.5 at temperature 30°C and relative humidity 90%. The obtained anisotropic films had been dried on free air during 60 min at temperature 60°C [13].

Photoluminescence (PL) was studied under excitation by 532-nm line of a cw Nd-laser using a thin film polarizer. Polarized PL spectra were recorded at room temperature with a LN-cooled charge-coupled-device (CCD) coupled to a grating spectrometer.

3. RESULTS AND DISCUSSION

The optical density spectrum of stretched PVA-film is different for different polarization of incident light enabling manifestation of either transverse or longitudinal plasmon mode in the extinction (Fig. 1).

Photoluminescence of both quantum dots and nanoplatelets containing films is partially polarized, the luminescence intensity being higher for polarization parallel to the stretching (alignment) direction.

Photoluminescence polarization degree defined as

$$P = \frac{I_{\max} - I_{\min}}{I_{\min} + I_{\max}},$$

for samples shown in Figs. 2, 3 was equal to $P_1 = 0.19$ and $P_2 = 0.27$ respectively.

4. CONCLUSIONS

In this work we have demonstrated an affordable approach to fabrication of light emitting polymer films in which partially polarized photoluminescence develops owing to plasmonic effects from aligned metal nanorods in a stretched film with colloidal II–VI nanocrystals and nanoplatelets as active centers.

ACKNOWLEDGMENTS

The work is supported by the Belarusian Basic Research Fund through Ф16T/A-010 project.

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