ThR09-p77

Site-controlled Ga(Al)As nanostructure arrays emitting at 740 nm

Chernenko N.E.[1], Makhov I.S.[2], Melnichenko I.A.[2], Balakirev S.V.[1], Kirichenko D.V.[1], Shandyba N.A.[1], Kryzhanovskaya N.V.[2], Solodovnik M.S.[1]*

[1] Laboratory of Epitaxial Technologies, Southern Federal University, Taganrog, Russia
[2] International Laboratory of Quantum Optoelectronics, HSE University, St. Petersburg, Russia
** solodovnikms@sfedu.ru*

21st INTERNATIONAL CONFERENCE LASER OPTICS ICLO 2024
1–5 JULY 2024
ST. PETERSBURG, RUSSIA

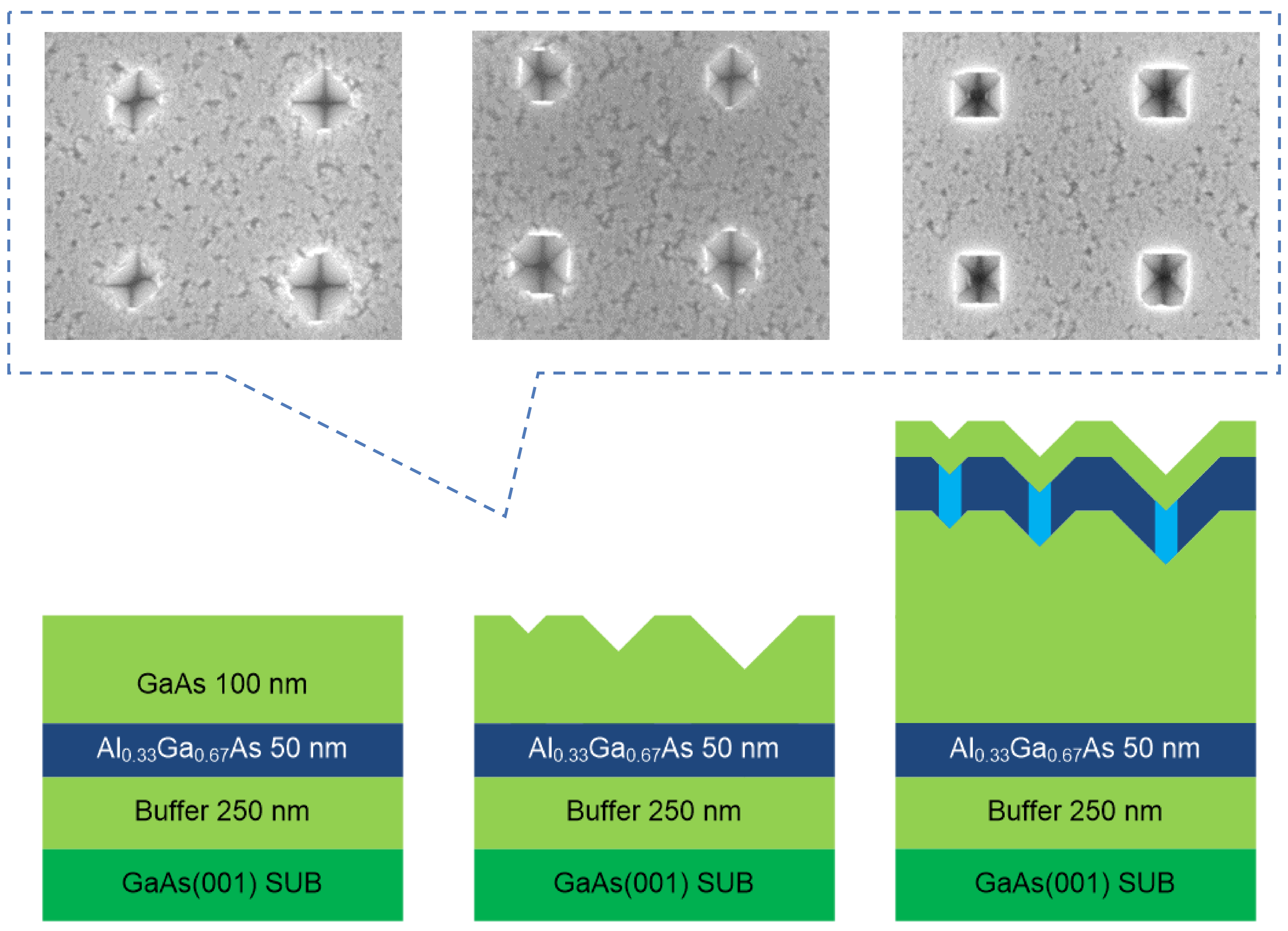
1

Single and entangled photon sources and act as the elementary basis of integrated optoelectronics, telecommunications, and quantum technologies. In turn, to create such radiation sources, it is necessary to develop a technology that will make it possible to obtain A3B5 epitaxial nanoheterostructures with adjustable arrays of quantum dots, as well as the ability to independently control the geometric parameters of individual quantum dots. To control self-organization processes, a promising approach is the preliminary structuring of the growth surface through the targeted formation of holes which act as centers of preferential nucleation of

In this work we presents the results of experimental studies of the formation processes and optical properties of ordered arrays of Ga(Al)As nanostructures on GaAs(001) substrates with regular arrays of pyramidal-shaped holes. The possibility AlGaAs solid solution on the structured surface decomposes with the formation of low-dimensional structures enriched by the Ga component is demonstrated. We have also shown that the emission wavelength (740 nm) of site-controlled Ga(Al)As nanostructures is practically independent of the patterned surface morphology, while the emission intensity is determined by the effective volume of nanostructures.

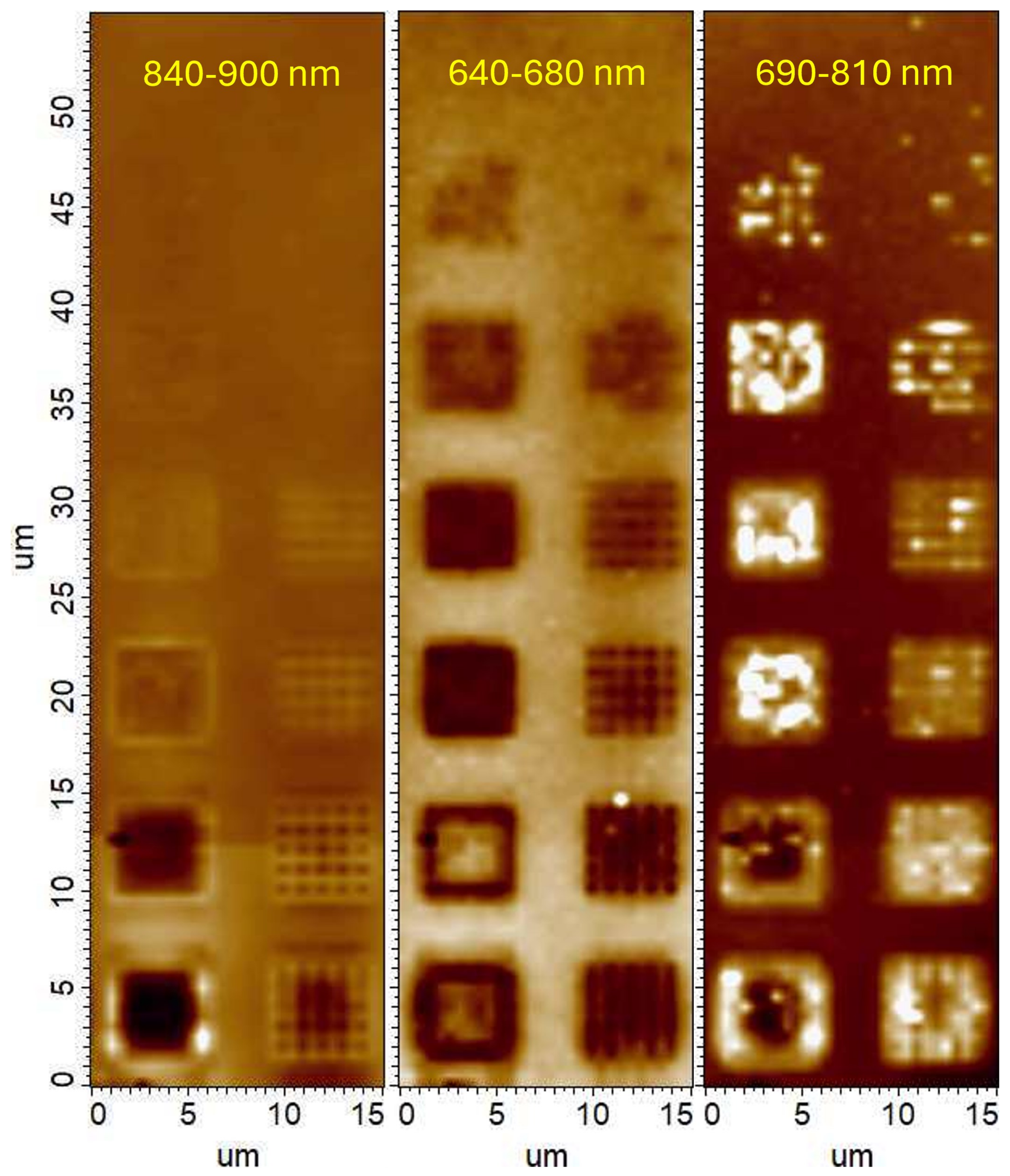
2

For experimental study we deposited AlGaAs layer with thickness of 50 nm and Al mole fraction of 33% on the GaAs(001) surface with regular arrays of pyramidal-shaped holes obtained by using a combined technique based on focused ion beam technologies and local droplet etching.



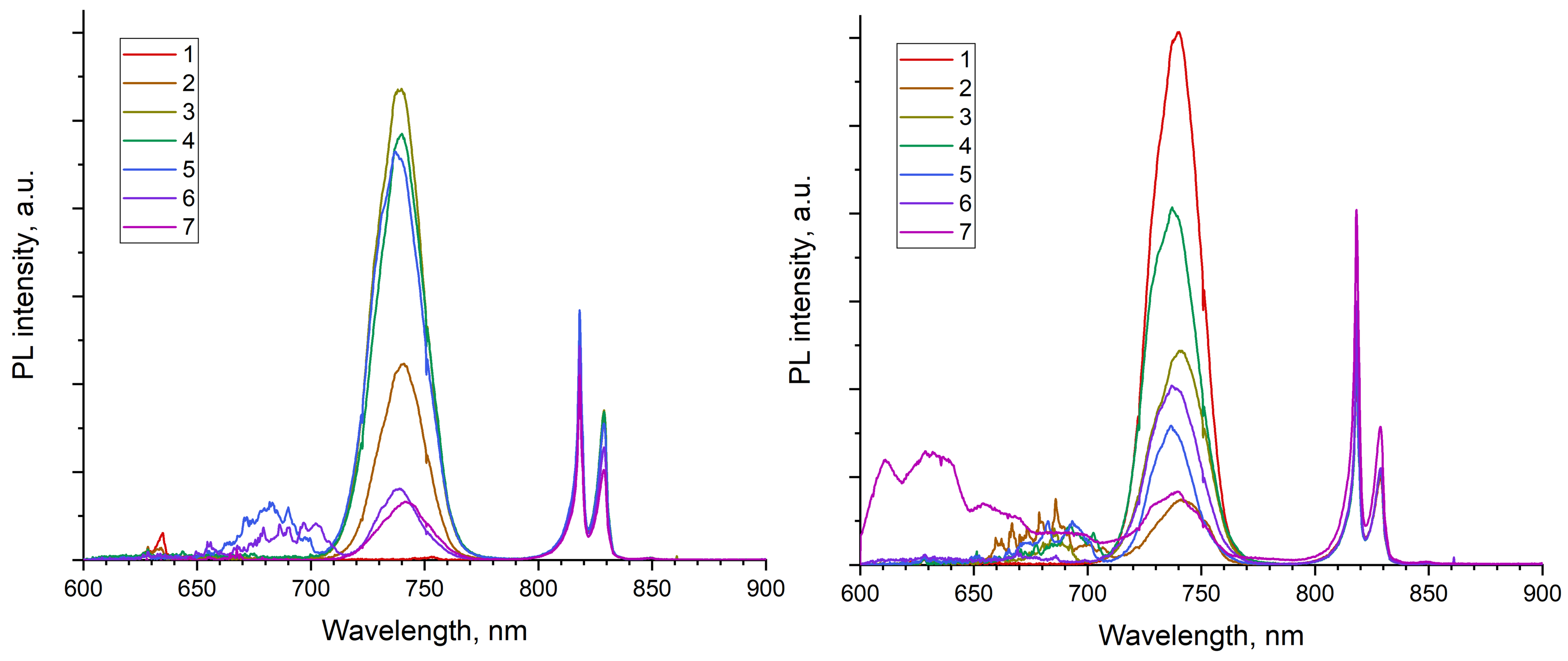
3

On the photoluminescence intensity distribution maps at 300 K, the minimum points in the spectral range of luminescence of GaAs (800 – 900 nm) and $Al_{0.33}Ga_{0.67}As$ (640 – 700 nm) correspond to intensity maxima in the wavelength range 700 – 800 nm which are associated with Ga(Al)As structures. .



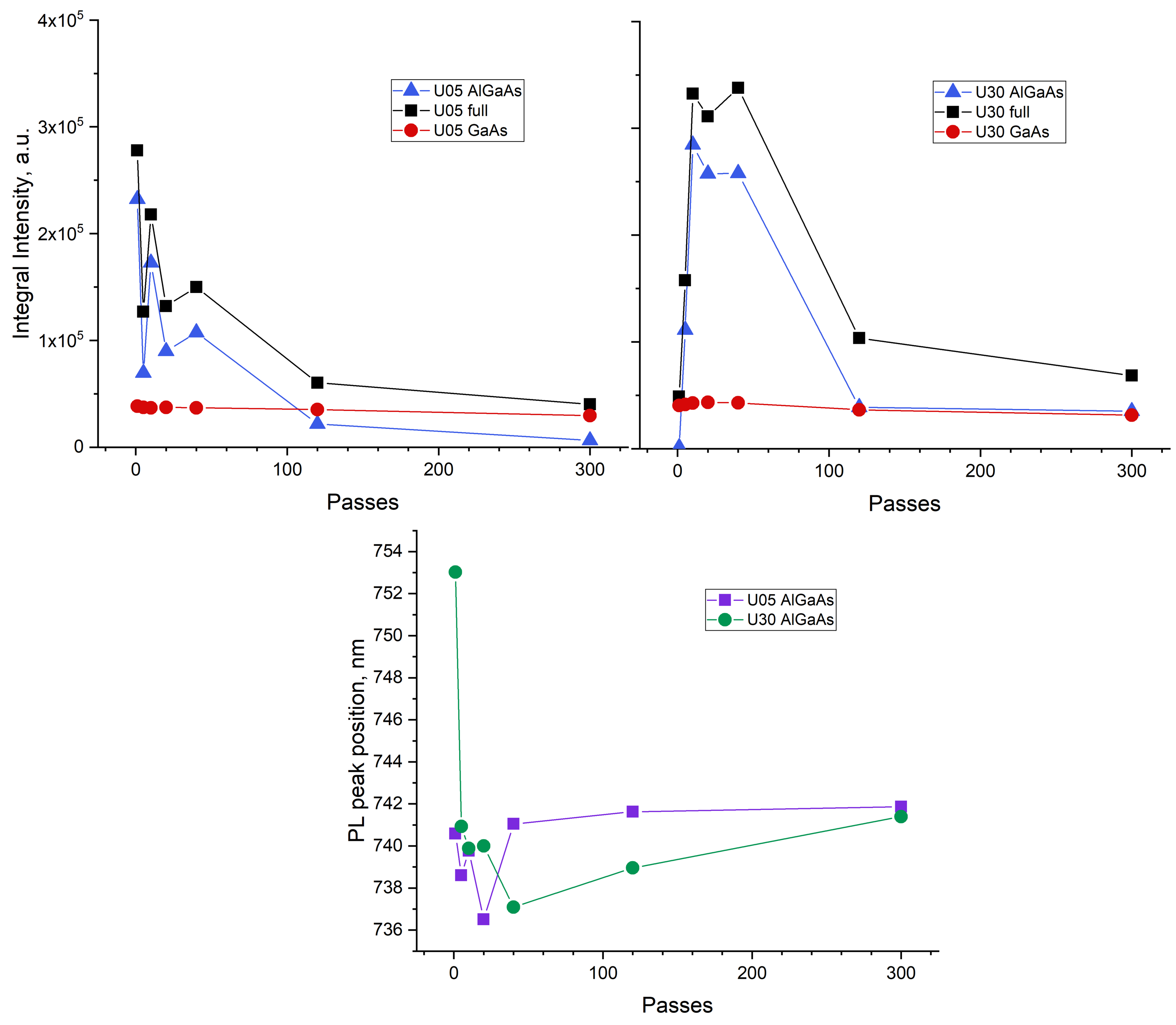
4

The high-intensity line near the wavelength of 740 nm (1.68 eV) is probably due to transitions in the quantum-sized Ga(Al)As/AlGaAs structures formed in the centers of the pyramidal holes. A wide shoulder of low intensity in the region of 650 – 700 nm can also be associated with the presence of regions with an intermediate composition, formed, for example, along the junctions of faces inside the holes.



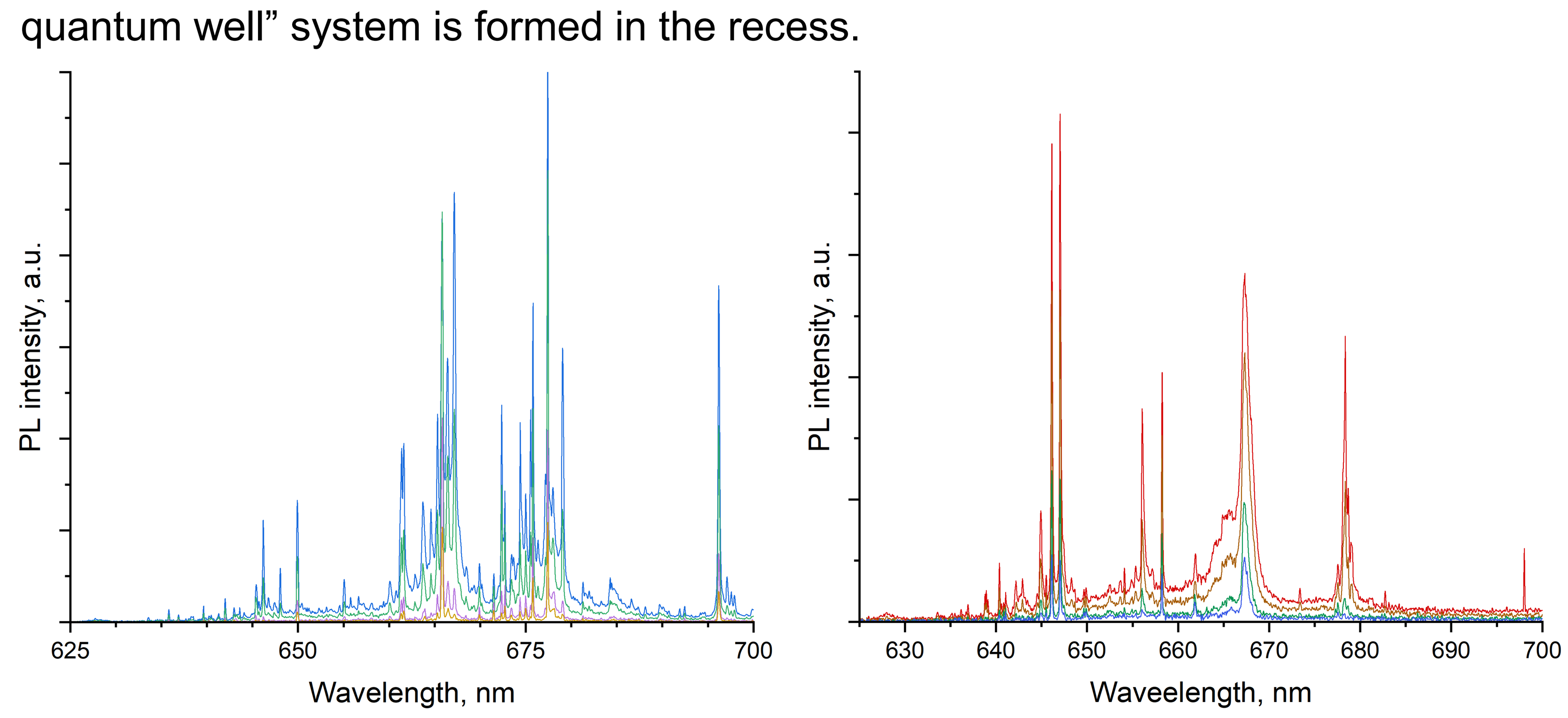
5

Dependences of the integral PL (5 K) intensities of Ga(Al)As and GaAs peaks and their contribution to the total spectra intensity on the number of ion beam passes, which determines the morphology of the arrays of nanoholes. It is clearly seen that the overall PL intensity is determined primarily by the contribution of Ga(Al)As nanostructures. Moreover, the emission wavelength of Ga(Al)As nanostructures does not depend on the array number.



6

A wide shoulder of low intensity in the region of 650 – 700 nm can also be associated with the presence of regions with an intermediate composition, formed, for example, along the junctions of faces inside the holes. Analysis of the PL spectrum in this range shows the formation of a set of narrow lines that can be associated with Ga(Al)As quantum dots formed during the enrichment of the nanoholes with Ga adatoms during deposition of AlGaAs layer. Thus, a "quantum dot + quantum well" system is formed in the recess.



This work was supported by the Russian Science Foundation Grant No. 22-79-10251 and by the Ministry of Science and Higher Education of the Russian Federation Grant No. FENW-2022-0034 at the Southern Federal University, and by the project "Mirror Laboratories" at the HSE University. Optical measurements were carried out on a large-scale facility "Complex Optoelectronic Stand".