Advanced Light-Emissive Device Structures

Sergei L. PYSHKIN[1,2]*

[1]*Institute of Applied Physics, Academy of Sciences of Moldova*
[2]*Clemson University, COMSET, SC, USA*
**spyshkin@yahoo.com*

Here is discussed the development of advanced and resource-saving method for fabrication of semiconductor materials having unique and close to ideal properties for optoelectronic devices. This work could lead to significant advances in understanding of semiconductor materials, enhancements to their performance, and the growth of high impact optoelectronics companies in the USA and Moldova.

The noted project is unique because I first have prepared a series of semiconductor samples as part of my graduate research more than 50 years ago and over those years, the samples have been repeatedly studied in research centers of Italy, Romania, Russia, the United States, and significant improvement in their quality and interesting properties were noted.

GaP was selected as highly promising material for various optoelectronic applications and also as a model material for investigation of fundamental properties of semiconductors. In particular, GaP doped with nitrogen N (GaP:N) is a unique object for the generation, investigation and application of bound excitons in ordered N-impurity superlattice. A summary of how have been effective past efforts discussed around the world during my first Fulbright Fellowship (2005-2006), as well in a lot of articles, conferences and in our 4 InTech open access books, serial “Optoelectronics” edited by me and Prof. John Ballato. Some optoelectronic device structures for infrared photoreceivers and advanced light emissive devices developed as part of the contracts with the US Air Force and Navy. The next problem will be proposed to the competent audience for further collaboration - Development of technology for growth of pure and doped perfect bulk GaP and its nanocrystals and methods of incorporation of the GaP nanoparticles into polymer films for light emissive device structures. Patent activity will be directed to investigation of the existing patented decisions. One positive US decision on patent application “A method of preparation of GaP Nanoparticles” already was obtained in December 2011 and the other 2 patent applications are under their consideration. Large-scale extension of our collaborative joint work will lead to new resource-saving methods of fabrication of the semiconductor materials having unique and close to ideal properties for optoelectronic devices. It is very timely that the final phase of this career-long study be completed given the scale of the global optoelectronic industry and the continued need for advanced optoelectronic materials and devices. Noted here as well is the widespread popularity of the work underlying this project and the interest of the scientific community. For example, the publishers of the Open Access Journal “Nanoscience & Technology” (NSTOA) have invited me to be the honored member of its Editorial Board and to write a review entitled “New Prospect for Optoelectronics” for the front pages of one of the 2015 issues and join me in promoting this project for implementation in practice of the leading enterprises in the electronics industry. Accordingly, these is urgent need to continue this work in the framework of the proposed by me and my US colleagues 2017 Fulbright Program as it is the most appropriate for the application the materials in the world's leading US electronic industry.

Thus, our half-of-a-century collection of results provide a new approach to the selection and preparation of perfect optoelectronics materials and a unique opportunity to realize a new form of solid-state host — the excitonic crystal. These results confirm expedience of the efforts directed to the formation in GaP of the N impurity superlattice having a lattice period equal to the bound exciton dimension. As we noted, high quality material for industrial electronics can be prepared by storing freshly grown crystals in a special storage. Only aged crystals with the attained necessary properties will be periodically retrieved for device fabrication while new portions of fresh crystals will be placed for further ordering at optimally selected conditions. The excitonic crystal, created by the long-term ordering or, as noted in 4 our books “Optoelectronics”, methods of growth of multi-layer films, will be used in new generations of optoelectronic devices. Tremendous commercial advantage can be achieved by using the perfect GaP crystals or materials of similar behavior and properties instead the further development of the existing very expensive and labor-intensive technologies for diverse imperfect materials.

All of the results presented here and included in our summary reviews may sufficiently change the approach to the selection of materials necessary for electronics, and to make cheaper and simpler technology for the preparation of the selected materials and device structures on which they are based. This study of long-term convergence of bulk- and nanocrystal properties brings a novel perspective to improving the quality of semiconductor crystals. The applicant’s unique collection of pure and doped crystals of semiconductors grown in the 1960s provides an opportunity to observe and understand the physics behind the long-term evolution of properties in these key electronic materials. The US top facilities will be used to see and publish our new results.