

RESEARCH OF AN ENERGETICAL SPECTRUM AND CHANNELS OF A RELAXATION OF ELECTRONIC EXCITATION IN THE NANOSTRUCTURAL CARBON FILMS

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Introduction

Last decade strong interest to creation of new film sources and amplifiers of coherent radiation is observed due the development of engineering of optical fibre communication. The first problem in this area there is an increase of intensity of radiation and efficiency of excitation on the length of a wave 1,54 microns appropriate to a minimum of attenuation and a dispersion in quartz optical paths. The second problem is increase of the coherence, monochromaticities and radiation orientations of nanosized structures for nanophotonics.

The first problem is solved in the first order for semi-conductor nanostructures (porous and nanocrystalline silicon, a-Si:H, SiGe/Si, GaN etc., alloyed by erbium). The second problem usually is solved for monocrystal matrixes (for example, garnet monocrystal films, alloyed by the rare-earth metals), however in them strongly show concentration suppression. Therefore it is difficult to receive very high specific capacity of radiation.

Results and discussion

In this work mechanisms of influence of matrix CN_xO_y on luminescence efficiency of ions Er^{3+} with wavelength 1,54 microns in nanocrystals ErO_xN_y are investigated. For finding out of concrete channels of energy transport of electronic excitation and realization of quantitative estimations of probabilities of these processes experimental researches of characteristics of a luminescence are carried out at high pressures which result in strong change of a power spectrum and population of laser levels of ion Er^{3+} . $CN_xO_y:Er,Si$ films was obtained by sol-gel method [1].

Chambers with the diamond and sapphire anvils were used for creation of the high pressure, allowing to receive pressure up to 15 GPa. Photo processing in the high pressure chamber was made both pulse, and continuous laser radiation with wavelength 442, 532, 630 and 1060 nm and power density of radiation up to 10^4 W/cm².



Fig. 1. The high pressure chamber with sapphire anvils ($P=10$ GPa, $\varepsilon=10^4$ W/cm²).

Influencing a high pressure and laser radiation, it is possible to form optically active nanocrystalline clusters in amorphous carbon films $CN_xO_y:Er,Si$. Nonlinear dependence of the cluster concentration from a doze and time of processing is found out. Optical absorption spectra of the carbon films $CN_xO_y:Re$ with various concentration optically active nanocrystalline clusters after photobaric processings were investigated.

Luminescence spectra of the $CN_xO_y:Er,Si$ films were experimentally investigated in the region 2,7-2,8 microns (transition $^4J_{11/2} \rightarrow ^4J_{13/2}$); 0,96-1,15 microns ($^4J_{11/2} \rightarrow ^4J_{15/2}$) and 1,47-1,67 microns ($^4J_{13/2} \rightarrow ^4J_{15/2}$). As is known [2], last laser transition is strongly extinguished and usually is not used. However, in our experiments at pressure in several GPa (the optical chamber with diamond anvils) the increase of luminescence intensity with increase of pressure was obtained. And at pressure 12,1 GPa the superluminescence on transition $^4J_{13/2} \rightarrow ^4J_{15/2}$ (1,54 microns) with simultaneous suppression of a luminescence on transitions $^4J_{11/2} \rightarrow ^4J_{13/2}$ and $^4J_{11/2} \rightarrow ^4J_{15/2}$. was observed (Fig. 2)

For understanding of a nature of the photoluminescence were investigated absorption spectra of the $CN_xO_y:Er,Si$ films at various pressure (fig. 3). Apparently from figure absorption band of CN_xO_y matrix are strongly displaced concerning energy levels of ion Er^{3+} at change of pressure that results in change of

overlapping of absorption bands of the matrix and levels of ion Er^{3+} . This overlapping changes population of laser levels and reduces the role of processes of interionic interactions, responsible for the energy transport (self-suppression and up-conversion to overlying levels $^4\text{J}_{9/2}$, $^4\text{F}_{9/2}$, $^4\text{S}_{3/2}$ etc.).

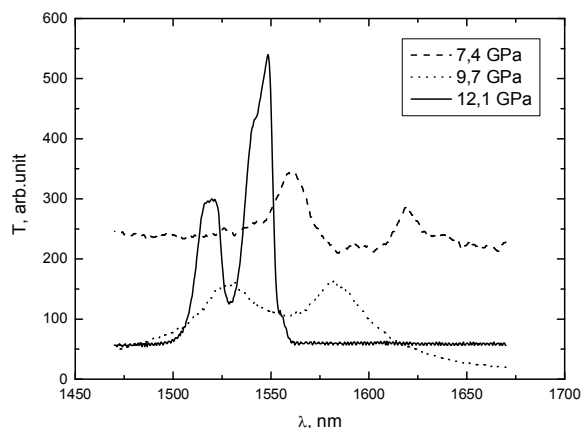


Fig. 2. Irradiation spectrum of $\text{CN}_x\text{O}_y:\text{Er,Si}$ films in the transition region $^4\text{J}_{13/2} \rightarrow ^4\text{J}_{15/2}$ of ion Er^{3+} .

Conditions of effective realization cross-relaxation mechanism of interionic interactions, according to work [3], consist in the relation of minimally possible accepted energy from the activator to the greatest possible given energy. Energy which may give ion Er^{3+} at transition $^4\text{J}_{11/2} \rightarrow ^4\text{J}_{13/2}$, according to measurements of absorption spectra and a luminescence, makes size E_{max} of $3500\text{--}3700\text{ cm}^{-1}$, and minimally accepted from matrix $\text{CN}_x\text{O}_y \sim 100\text{ cm}^{-1}$.

Therefore strong change of probability of nonradiative energy transport from levels $^4\text{J}_{11/2}$ and $^4\text{J}_{13/2}$ is observed.

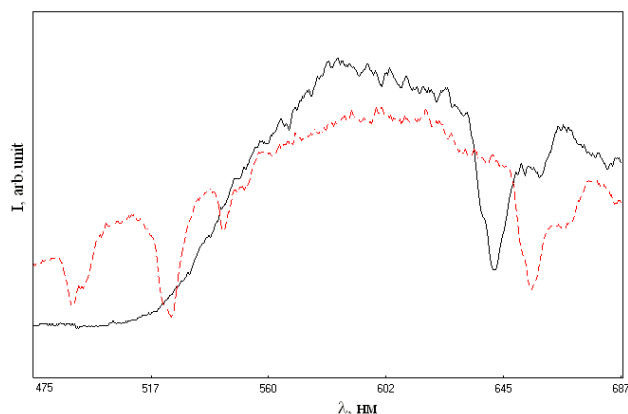


Fig.3. Absorption spectrum of $\text{CN}_x\text{O}_y:\text{Er,Si}$ films at normal pressure (dotted line) and pressure 7,4 GPa.

Conclusions

1. It is allocated the new optically active centre ErO_xN_y forming the linear photoluminescence spectrum in the spectral region of 1,5 microns (0,83 eV). The analysis of its energetical structure is carried out.
2. Abnormal compression Stark splittings of levels of ion Er^{3+} connected with strong spatial localization is registered.
3. The possibility of radical increase of efficiency light-emitting nanostructures in the graphitic films at photobaric processing is experimentally shown.

References

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