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# ERBIUM Photoluminescence Centers in Silicon

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**ABSTRACT:** The states of erbium impurity atoms in crystalline and amorphous silicon are studied by Mössbauer emission spectroscopy and it has been established that $[Er-O]$ clusters are optically active centers.

**KEYWORDS:** Photoluminescence, center, cluster, amorphous, crystalline, emission, spectrum, material, impurity, sample, technology, dispersion.

## I.INTRODUCTION

The phenomenon of photoluminescence (PL) in crystalline (c-Si) and amorphous hydrogenated silicon (a-Si: H) doped with erbium (c-Si <Er>, a-Si <Er>), opens up the prospect of using these materials for the manufacture of photos - and electroluminescent devices integrated into silicon technology and operating at a wavelength corresponding to a minimum of losses and a minimum dispersion in fiber-optic communication lines.

It is known that the PL intensity depends on the concentration of erbium N (Er) and increases if an admixture of oxygen is introduced along with erbium. In c-Si <Er> samples containing ~ $10^{17}$ $cm^{-3}$ oxygen, the optically active center is a cluster consisting of erbium and oxygen atoms $[Er-O]$, and the local environment of erbium is close to its environment at $Er_2O_3$. However, a decrease in the oxygen concentration to ~ $10^{15}$ $cm^{-3}$ leads to a rearrangement of the environment of erbium ions and it becomes characteristic of $Er\,Si_2$. A theoretical consideration of the process of PL excitation in c-Si <Er> also leads to the need to consider a radiating cluster $[Er-O]$, which is a quantum dot with a size of ~ $10A$ . We also note that c-Si <Er> is characterized by strong quenching of the PL in the temperature range 77-300 K, while for $a-Si:H<Er>$ the PL intensity at room temperature is two orders of magnitude higher than in c-Si <Er>. Obviously, this indicates a difference in the structure of the emitting centers for crystalline and amorphous materials or a change in the electronic structure of silicon.

In this work, in order to identify the photoluminescence centers of erbium in c-Si and a-Si: H, we studied the state of erbium impurity atoms by Mössbauer emission spectroscopy using $^{169}$Er ($^{169}$Tm) isotope.

Monocrystalline c-Si <Er> was obtained by diffusion doping of c-Si containing ~ $10^{17}$ or ~ $2\cdot10^{19}\,см^{-3}$ oxygen: the erbium concentration in the samples was $5\cdot10^{18}\,см^{-3}$, and the thickness of the uniform doping layer was ~ 50 μm. A-Si: H <Er> films were obtained by magnetron sputtering of a metal erbium target in an atmosphere of silane and argon at a temperature of 3000 C: the oxygen concentration was $5\cdot10^{21}\,см^{-3}$, the hydrogen concentration was in the range from 9 to 11 at%, and the erbium concentration was varied from $10^{19}$ up to $10^{21}$ $cm^{-3}$.

Mössbauer sources were obtained by irradiating c-Si <Er> and a-Si: H <Er> samples with a thermal neutron flux of ~ $5\cdot10^{18}\,см^{-2}$. Mössbauer spectra were measured on an SM-2201 industrial spectrometer at 295 K with an absorber in the form of thulium ethyl sulfate (surface density 5 mg/$cm^2$ for thulium). Typical Mössbauer spectra of Si: $^{169}$Er are a superposition of a quadrupole doublet (spectrum I) and a single line (spectrum II). The ratio of the areas under the spectra of I to II depends on the type of matrix (amorphous or crystalline), erbium concentration and oxygen concentration.

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The interpretation of the Mössbauer spectra of $^{169}$Er ($^{169}$Tm) was carried out under the assumption that, as a result of the thermal neutron capture reaction $^{168}Er(n,\gamma)^{169}Er$ and the subsequent $\beta-$ decay of $^{169}$Er, a $^{169}$Tm Mössbauer probe appears in erbium sites. Although there is no isomeric shift in the Mössbauer spectra of $^{169}$Tm, the magnitude of the quadrupole splitting substantially depends on the symmetry of the local environment of the probe and, thus, emission Mössbauer spectroscopy allows obtaining information on the symmetry of the local environment of erbium atoms.

The spectra of c-Si <Er> and a-Si: H <Er> samples correspond to two states of erbium impurity atoms in the material structure, with spectrum I corresponding to erbium centers with reduced symmetry of the local environment, and spectrum II to erbium centers in almost regular cubic environment . Thus, as a result of the study, it was found that the $[Er-O]$, clusters are the optically active centers in crystalline and amorphous silicon doped with erbium and oxygen, and the local symmetry of ions $Er^{3+}$ in these clusters is similar to that in $Er_2O_3$.

## REFERENCES

1. H. Ennen, J. Schneider, G. Pomrenke, and A. Axmann, Appl. Phys. Lett. 43, 943 (1983).

2. H. Ennen, G. Pomrenke, A. Axmann, K. Eisele, W. Haydl, and Jchneider, Appl. Phys. Lett. 46, 381 (1985).
3. M. S. Bresler, O. B. Gusev, V. Kh. Kudoyarova, A.N. Kuznetsov, P. E. Pak, E. I. Terukov, I. N. Yassievich, and B. P. Zaharchenya, Appl. Phys. Lett. 67, 3599 (1995).
4. E.I. Terukov, V. Kh. Kudoyarova, M. M. Mezdrogina, V. G. Golubev, A. Sturm, and W. Fuhs, Sov. Phys.- Semiconductors 30, 440 (1996).
5. A. Polman, G. N. van den Hoven, J. S. Custer, J. H. Shin, R. Serna, and P. F. A. Alkemade P. F. A.? J. Appl. Phys. 77, 1256 (1995).