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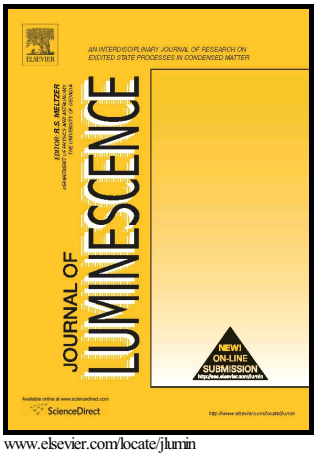

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Luminescence of SiO_2 layers on silicon at various types of excitation.

Baraban AP[1], Samarin SN[1,2], Prokofiev VA[1], Dmitriev VA[1], Selivanov AA[1], Petrov Y[1]

[1]St. Petersburg State University, St. Petersburg, 198504, Russia

[2]School of Physics, the University of Western Australia, Perth WA 6009, Australia

Abstract

We present a comparative analysis of Cathodoluminescence (CL), Photoluminescence (PL) and Electroluminescence (EL) spectra measured on Si-SiO2 structures with various thicknesses of SiO_2 layer. The spectral distributions of the luminescence depend on the technology of the SiO_2 layer formation, on its thickness and the type of excitation. The analysis indicates that CL and EL spectra of the Si-SiO_2 structures, grown by thermal oxidation of silicon in a "dry" oxygen, are almost identical in spectral composition. The PL of the Si-SiO_2 structures provides additional information about the optically active centres in the SiO_2 layer. The PL spectra allow tracking changes in the SiO_2 layer while increasing its thickness in more detail than the EL and CL. We suggest that there is a substantial difference in the excitation mechanisms of luminescence by electrons (CL and EL) and photons (PL). Therefore, in general case, the luminescence centres identified in PL cannot be directly used for the interpretation of CL and EL spectra. However, analysis of the PL and EL spectra before and after the field degradation of the Si-SiO_2 structure as well as analysis of PL spectra of the oxide layers formed by various technologies shows that the model of luminescence centers proposed for red photoluminescence is acceptable for the red luminescence excited by electrons in Si-SiO_2 structure.

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I. INTRODUCTION

Luminescence is widely used in fundamental studies of solid structures, including semiconductor-dielectric interfaces [1-3]. The luminescent properties of such structures are attracting researchers because of their potential applications in optoelectronic devices based on silicon technology. For this reason the processes of electroluminescence of modified silicon oxide layer are of a great interest. The oxide layer is modified by changing its composition and / or stoichiometry using, for example, an ion implantation [4, 5]. These modifications allow to control the intensity of the luminescence and its spectral composition. Electronic properties of thermally grown unmodified SiO_2 films are also investigated using various methods of excitation of luminescence [2,3,5-7].

The spectral distribution of the luminescence of original and modified SiO_2 layers has a rather complicated structure, containing a set of bands and maxima, most common of which are located in areas of 650 - 660 nm (1.9 eV), 539 - 564 nm (2.2 - 2.3 eV) , 443 - 477 nm (2.6 - 2.8 eV) and 282 - 288 nm (4.3 - 4.4 eV). These features indicate a presence of a number of various luminescent centers related presumably to various defects in the SiO_2 layer. The main contribution to the luminescence is made by the defects associated with disturbances in one