Cathodoluminescence of Thermoregulating Composite Materials

V.V. Harutyunyan1,*, E.M. Aleksanyan1, A.H. Badalyan1, N.E. Grigoryan1, V.S. Baghdasaryan1, A.A. Sahakyan1, V.V. Baghramyan2, A.A. Sargsyan2

1A.I. Alikhanian National Science Laboratory, Yerevan Physics Institute, 0036 Yerevan, Armenia
2Institute of General and Organic Chemistry of Armenian National Academy of Sciences, Yerevan, Armenia
* vharut@mail.yerphi.am

Silicates and other refractory composite thermoregulating coatings (TRC) form a basis of technically important products and articles such as "solar reflectors" for space vehicles. TRC properties crucially depend on the peculiarities of their structure at the atomic level such as their chemical bond, defectiveness, and nature of defects in crystal lattices.

The work presented is aimed at the study of optical characteristics (cathodoluminescence) of zirconium silicate obtained by hydrothermal microwave synthesis.

The cathodoluminescence (CL) experiments were performed using a special installation. CL spectra (ZrO2 and SiO2) were measured within the temperature range of 77 - 300 K using a low temperature cryostat. CL excitation was performed using a compact electron accelerator with the following beam parameters: adjustable electron energy of 1 - 30 keV and electron current of 10 - 100 nA. When TRC are exposed to 10keV and 5keV pulsed electron beams at different temperatures, an intense luminescence is observed within the spectral range of 2.75 eV - 3.5 eV. CL spectrum at 78 K is a broad band with a maximum shifted depending on the excitation energy (2.75 eV - 3.5 eV). With increasing temperature (300 K), a decrease of CL intensity is observed, and the maximum of luminescence band becomes 3.0 eV. Excitation of CL in TRC within the spectral range of 1-5 eV by pulsed electron beams of different energies has revealed that the intensity of the CL spectra depends strongly on the excitation energy. 2.75eV, 3.0eV and 3.25eV bands observed in the CR spectra of the studied TRC (ZrO2 and SiO2) are characteristic of luminescence of many silicates and are usually associated with radiation of defect centers. Zirconium ions may be located in tetrahedral surrounding in the form of (OH) - Zr – (OSi)3 or Zr – (OSi)4 and [SiO4]4- groups due to the presence of zirconium ions and local distortions of silicon- oxygen tetrahedra. [SiO4]4- center occurs in the case of violation of the symmetry of silicon-oxygen tetraedra because of a nearby defect. In the formation of above centers and their metastable states, impurities can play an important role: as charge compensators or as the factors of change in electron density distribution of the tetrahedra. Zr ions may be formed at bond breaking - the optical transitions in VZr– center.