

Mechanisms of Impact on Luminescent Properties of Thermoregulating Materials

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Study of the luminescence of thermoregulating coatings (TRC) or the pigments obtained by different methods not only allows obtaining ideas of the composition and structure of these materials, but also has practical importance when developing light sources, fluorescent biosensors, solar energy devices, space materials science, etc.

The luminescent properties of TRC were investigated using LUMEN pilot installation. The installation provides ample opportunities for research in the field of luminescent UV-visible spectroscopy with energy resolution at different temperatures. The power of the radiation spectrum of xenon lamp as the source of radiation within 240-360 nm was 1000 watt.

The work was aimed at the influence of various factors (annealing, electron irradiation, impurities) on the photoluminescence (PL) excitation mechanisms of TRC.

Study of photoluminescence (PL) of TRC containing zirconium (ZrO nSiO₂) and zinc (ZnO₂SiO₂) has revealed two broad bands of radiation, UV and visible, in them.

When acting on TRC (ZrO nSiO₂) treated at various temperatures by UV photons (having excitation energy $E_{exc} = 3.5\text{eV}$), an intense luminescence within the spectral range of 1.8 eV - 2.6 eV is observed with the emission band maxima shifted depending on the treatment temperature, which confirms the possibility of various mechanisms of excitation for radiation centers. With an increase in the treatment temperature, a decrease in the PL intensity takes place, and the luminescence band maximum is observed at 1.9 eV, 2.2eV, 2.4eV and 2.6eV bands observed in the PL spectra of the studied TRC (ZrO nSiO₂) are characteristic of luminescence of many silicates and are usually associated with radiation of, for instance, $[\text{SiO}_4]^{4-}$ defect centers which are due to local distortions of silicon- oxygen tetrahedra. Zirconium ions may be located in tetrahedral surrounding in the form of (OH) - Zr - (OSi)₃ or Zr - (OSi)₄ groups. The position of $[\text{SiO}_4]^{4-}$ center is more beneficial and occurs in the case of violation of the symmetry of silicon-oxygen tetrahedra because of a nearby defect. When the studied TPC contains zirconium and zinc ions, 5 MeV electron irradiation leads to a shift of maxima in PL spectra as a result of redistribution of the defective emission centers formed during the heat treatment: short-living defects in the form of V_{Zr}^- vacancies and Zn^+ interstitial ions formed at bond breaking - the optical transitions in V_{Zr}^- center. The changes in the PL spectra of (ZnO nSiO₂) TRC samples after heat treatment can be explained if we assume that the observed maxima at 1.7 – 2.6eV are due to the creation of intrinsic defects in the tetrahedral structure. In the formation of the impurity centers and their metastable states, the impurity concentration can play an important role in view of possible changes in the electron density distribution of ZnO nSiO₂ tetrahedron.

Thus, photoluminescence in silicate TRC is due to the multicomponent defect centers inherent in silicate materials and is efficiently excited within the UV radiation region.