LOW TEMPERATURE DEPENDENCIES OF UV EXCITED LUMINESCENCE SPECTRA FOR TSAREV CHONDRITE

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Introduction: It is known that Tsarev L5 meteorite have undergone postmetamorphic reheating followed by fast cooling [1 – 3]. As a result the chondrite has black lithology, different silicate phases of which show a strong optical absorption due to light scattering by pervasive metal particles [1, 4]. Nevertheless unlike, for example, Chelyabinsk LL5 chondrite fragments with prevailing dark-colored lithology, Tsarev demonstrates an intensive laboratory luminescence response to various external excitations such as temperature, ionizing radiation, etc. Recently we have study spectral and kinetic properties of irradiated Tsarev L5 chondrite using photo- (PL) and thermoluminescence methods at high temperatures of 300 – 873 K [4, 5]. At the same time, the analysis of optical processes at cryogenic temperatures, when non-radiative transitions in most silicates are frozen-in, has a fundamental importance. In this case, the estimation of microparameters for differnet interacting optically active centers is more reliable and is not distorted by electron-phonon effects. Thus, in this work the variations of UV excited PL parameters for Tsarev L5 chondrite in the low temperature range from 7 to 300 K are analyzed.

Experimental: Several samples of Tsarev meteorite L5 chondrite were studied. The core of the meteorite was separated from fusion crust and crushed into micropowder, which was treated in hydrochloric acid to remove metal particles. PL emission was excited by ultraviolet pulsed radiation from the DTL-389QT solid-state laser (Laser-Export, LLC) with a wavelength of $\lambda = 263$ nm and with pulse repetition frequency of 1 kHz. The laser radiation power was 12 mW at the sample location. PL signal was measured using a Shamrock SR-303i-B spectrograph (Andor, Inc.) with a diffraction grating of 150 mm^{-1} stroke number and with efficiency maximum at $\lambda = 500$ nm, as well as a cooled Newton EM DU970P-BV-602 CCD matrix (Andor, Inc.). The temperature of the matrix during the registrations was stabilized by 193 K. The width of the spectrograph entrance slit was 50 μm. To eliminate the influence of the laser radiation scattered by the sample, BS-8 optical filter (Electrosteclo, LLC) was used. Data from the CCD were read in full vertical binning mode under 10 s exposure time. The experimental spectra were averaged over 10 independent measurements. The temperature of the sample was changed by means of a CCS-100/204N helium cryostat (Janis Research Company, LLC) with a closed loop equipped with DT-670B-CU sensor, HC-4E compressor and 335 Model controller (Lake Shore Cryotronics, Inc.). The pressure inside the cryostat was maintained by HiCube 80 Eco vacuum pumping station (Pfeiffer Vacuum, LLC) at a level of $P \leq 10^{-4}$ mBar. PL spectra were recorded in the range of $\lambda = 350$ – 900 nm at different temperatures: T = 7 K, in 10 – 100 K range in steps of 10 K and from 100 to 300 K in steps of 20 K.

Results and Discussion: The UV excited PL emission data at different temperatures are presented. It is shown that the PL spectra are characterized by two wide bands – S1 and S2 – in ranges of 400 – 600 nm and 650 – 850 nm, respectively. The following features of the PL spectra evolution at investigated temperatures are revealed. The maximum intensity in S2 band is ≈ 1.2 times higher than the intensity in the S1 band at T = 300 K. With decreasing temperature, the observed PL maxima shift from 510 to 485 nm (for S1) and from 723 to 750 nm (for S2). It is shown that all the experimental PL spectra in the S2 range are satisfactorily approximated by single peak of the Gaussian shape with $R^2 > 0.995$ coefficient of determination. At the same time, the band is insignificantly narrowed from 0.33 ± 0.01 to 0.28 ± 0.01 eV with a change of temperature from 300 to 7 K. Quantitative analysis of the PL spectra parameters for the S1 band is also performed. It is shown that a broad emission curve consists of at least three subbands with $E_{max} \approx 2.4$, 2.8, and 3.2 eV. The origin of the observed PL bands is discussed in comparison with the independent data for the Tsarev meteorite under study and other ordinary chondrites [6, 7]. The temperature dependencies of the PL integral intensity within the investigated spectral ranges are analyzed in the framework of the Mott [8] and Street [9] models in presence of thermally activated and disorder-induced non-radiative channels. The activation energy of $E_q = 54 \pm 5$ meV for PL thermal quenching is estimated in S2 spectral range. The possible common mechanisms of luminescence quenching in chondrites with various silicates content are discussed.

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