UV EXCITED LUMINESCENCE OF CHELYABINSK LL5 CHONDRITE SILICATES IN 7 – 340 K TEMPERATURE RANGE

S. S. Savchenko, A. S. Vokhmintsev and I. A. Weinstein
Ural Federal University, Mira street 19, Yekaterinburg, Russia, 620002, s.s.savchenko@urfu.ru

Introduction: It was previously shown that fragments of the Chelyabinsk meteorite with light lithology dominating have various luminescence phase composition from the olivine and the group of multicomponent pyroxenes [1, 2]. The variety of silicates, their quantitative composition, radiation history, numerous structural and other transformations significantly effects photo- and thermally stimulated processes for different fragments of the same meteorite [1 – 4]. Thus, the selective study of the luminescent properties of individual silicate grains is a relevant material science challenge. At the same time, the analysis of optical processes at cryogenic temperatures for individual phases is of fundamental interest, when non-radiative transitions in most silicates are frozen-in. In this case, the estimation of microparameters for different interacting optically active centers is more reliable and is not distorted by electron-phonon effects. In this regard, the work aimed at studying the spectral and temperature features of the photoluminescence behavior of individual silicate grains from Chelyabinsk chondrite in the range of 7 – 340 K.

Samples and Technique: A fragment of Chelyabinsk LL5 chondrite predominantly characterized by light-colored lithology was selected. A core of the meteorite was separated from fusion crust and crushed into micropowder. Individual grains of silicates ~ 10 μm in size were isolated from the obtained powder. Optical and PL images of the samples under study were obtained by means of an Axio CSM 700 confocal optical microscope (Carl Zeiss, Inc.) and a LUMAM I3 luminescence microscope (LOMO, Inc.) with an EOS 650D digital SLR camera (Canon, Inc.), respectively. A DTL-389QT solid-state laser (Laser-Export, LLC) with a wavelength of λ = 263 nm was used to excite luminescence response. PL signal was registered via a Shamrock SR-303i-B (Andor, Inc.) and a cooled Newton^{EM} DU970P-BV-602 CCD matrix (Andor, Inc.). The sample temperature was varied using a CCS-100/204N closed loop helium cryostat (Janis Research Company, LLC) equipped with a DT-670B-CU sensor, HC-4E compressor and Model 335 controller (Lake Shore Cryotronics, Inc.). PL spectra measurements were performed in 350 – 900 nm range at the following temperatures (T): 7 K, in 10 – 100 K range with a step of 10 K and from 100 to 340 K incremented by 20 K.

Results and Discussion: The investigated silicate grains are found to exhibit blue-white (BW) and white (W) luminescence. The PL curves of BW grains are characterized by two wide structureless bands with maxima at ≈ 2.5 eV (490 nm) and ≈ 1.8 eV (680 nm) in the spectral range under study at T = 300 K. The emission of W grains also reveals two components peaked at ≈ 2.3 eV (540 nm) and ≈ 1.8 eV (690 nm). Moreover, BW and W grains have a different intensity ratio of the detected bands. The emission in the 2.5 eV band dominates in the BW grains, while for the W grains the 1.8 eV band prevails. Ratio of maximum intensities of the observed emission bands has a complex temperature dependence. The obtained results for BW grains are in reasonable agreement with our preceding PL studies of individual fragments and powder of the Chelyabinsk meteorite in 7 – 300 K temperature range [1, 5]. W grains are found to exhibit the following PL spectra peculiarities in the studied temperature range. As T decreases, the luminescence intensity and area under the curve drops by a factor of 2 in the 2.3 eV band and increase by a factor of 4 in the 1.8 eV band. In this case, the position of the 2.3 eV band is not changed, and in the 1.8 eV band the 0.06 eV red shift occurs as T varies from 340 to 7 K. It was shown that all experimental PL spectra in the 1.8 eV band are satisfactorily approximated (the determination coefficient R^2> 0.995) by a single Gaussian peak. The nature of the recorded PL bands is discussed in comparison with independent data for the studied chondrite and the Tsarev meteorite [6, 7]. The analysis of the temperature dependences of the maximum PL intensity in the bands under study for various grains was carried out within the framework of the Mott-Seitz luminescence model with one and two non-radiative channels [8, 9]. W grains reveals two non-radiative relaxation pathways with the activation energies of E_q = 70 ± 10 meV and 5 ± 1 meV at T = 70 – 340 and 7 – 70 K ranges, respectively. The possible PL quenching mechanisms and origin of related optically active centres are discussed.

References: [1] Popova O.P. et al. 2013. *Science* 342: 1069–1073. [2] Kohout T. et al. 2014 *Icarus* 228: 78–85. [3] Weinstein I.A. et al. 2014. *Meteoritics & Planetary Science* 49: A428. [4] Vokhmintsev A.S. and Weinstein I.A. 2017. *Meteoritics & Planetary Science* 52: A371. [5] Vokhmintsev A.S. and Weinstein I.A. 2018. *Meteoritics & Planetary Science* 53: 6304. [6] Vokhmintsev A.S. et al. 2015. *Meteoritics & Planetary Science* 50: A5200 [7] Weinstein I.A. et al. 2018. *Meteoritics & Planetary Science* 53: 6319. [8] Weinstein I.A. et al. 2006. *Tech. Phys. Letters* 32: 58–60. [9] Vokhmintsev A.S. et al. 2019. *Radiation Measurements* 124: 35–39.

Acknowledgments: The work was supported by Act 211 Government of the Russian Federation, contract № 02.A03.21.0006 and by Minobrnauki initiative research project № 16.5186.2017/8.9. S.S.S. thanks RFBR research project № 18-32-00664 for support.