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Thermostimulated exoelectron emission (TSEE) from the surface of laser-irradiated silicate glasses

L. Lewowska, St. Szarska, E. Rysiakiewicz-Pasek

Institute of Physics, Technical University of Wrocław, 50–370 Wroclaw, Wybrzeże Wyspiańskiego 27, Poland.

In the earlier investigations it has been stated that photosensitive, crystallizing silicate glasses exhibit TSEE [1, 2]. The maxima of emission have been observed at 330°C and 550°C. The first maximum was related to defects of glass structure, and the second one to the crystallization process of glass. The crystallization of glass is activated by silver atoms. In this paper the influence of laser radiation on TSEE in the range of the first maximum was investigated. For investigations we have used the glass of following composition (in percentage by weight): SiO_2–77.5%, Li_2O–10.8%, Al_2O_3–8.3%, K_2O–3.0%, Na_2O–0.55%, Ag–0.2%, SnO_2–0.01%, Ce_2O_3–0.03%. The glass differs slightly from glasses investigated in [1, 2] by composition of basic constituents of glass (SiO_2, Li_2O, Al_2O_3, K_2O) and by an additional content of 0.55% of Na_2O. It exhibits good optical homogeneity and reproducibility of physical properties [3], its optical transmittance is presented in the Fig. 1. After X-ray or UV from mercury lamp irradiation there appears the absorption band with the maximum at about 340 nm (Fig. 2). For samples irradiated with X-rays this maximum is several times higher than in those exposed to UV radiation. The samples can be bleached by heating to 330 °C.

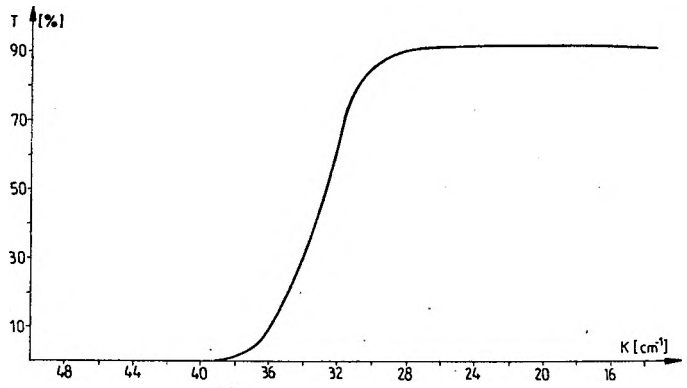

Fig. 1. Optical transmittance curve of a glass

This paper presents results of TSEE measurements for glass samples irradiated with: mercury lamp, Ar^+ laser, and N_2 laser. The mercury lamp was provided with a glass filter translucing for light in the range of 300–400 nm wavelength. The N_2 and Ar^+ lasers emit light of wavelengths 337 nm (UV line) and 514 nm (green line), respectively. Mean power per surface unit of irradiated samples was the greatest for Ar^+ laser and amounted to ~ 50 W/cm^2. The N_2 laser was working in impulse system, its frequency amounted to 30 Hz, time of one pulse being 10 ns. In each pulse the power per surface unit was about 10^5 W/cm^2 pulse. The mean power was comparable with mercury lamp power and was a fraction of watt. The exposure time ranged from 5 to 90 minutes.

During the measurement the samples were heated in the air atmosphere at the constant rate 1 K/s. As a detector of exoelectrons we have used the aerial point Geiger counter with quanching etanol vapour over the free liquid surface [4], cooperating with the typical electronic set. The counting rate was recorded in logarithmic scale.

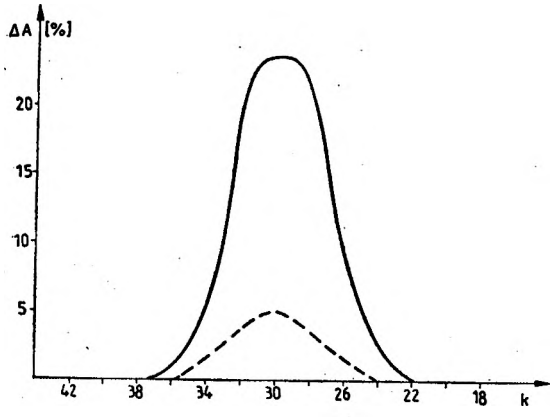

Fig. 2. Absorption band of a glass: solid line – the sample irradiated with X-rays, dotted line – th sample exposed to UV radiation

TSEE curve for not irradiated glass sample is presented in Figure 3. Irradiation with green Ar^+ laser as well as with mercury lamp does not change the shape of the curve. For samples irradiated with ultraviolet N_2 laser the run of TSEE curve is different: first maximum

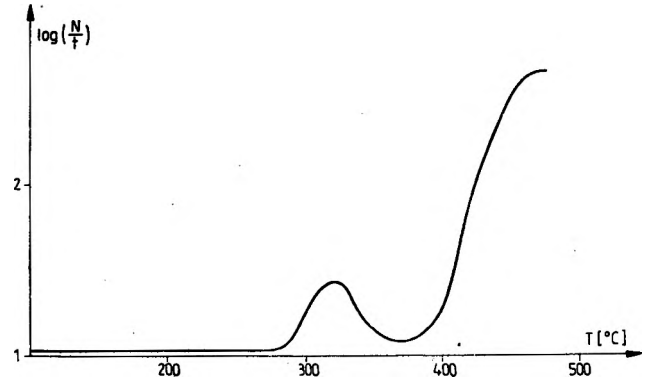

Fig. 3. TSEE curve from nonirradiated glass sample

appears at a little lower temperature and its height is about ten times greater (Fig. 4, dotted line). Moreover, for many samples an additional maximum appeared at 380 °C (Fig. 4, solid line), and was observed for a greater number of samples, if the irradiation time was shorter. Irradiation of samples with N_2 laser did not give absorption band at 340 nm. Since after irradiation with laser light of 337 nm wavelength exoelectron emission was much higher than that from samples irradiated by other sources, it seems to be connected with surface damage by pulsing laser action. For this reason, the sample surface was examined using a scanning electron microscope with 1000 x magnification, but no damage of sample surface was detected. This observation is in agreement with results obtained by KHASOV [5] for other sort of glasses from light scattering investigations. According to [5], the surface damage occurred when incident radiation energy exceeded 30 J/cm^2 pulse, this value being by 4 orders of magnitude greater than the surface energy density of the N_2 laser radiation used.

The data concerning exoelectron emission accompanying boron-silicate glass and quartz radiation by pulse ruby laser of high power are known from paper [6]. Density of current generated by each light pulse amounted to 10^{10} electrons/mm^2, but there was no damage of surface after irradiation. The difference between microscopic image of not irradiated and irradiated surfaces was observed only after heating during TSEE measurement. On the surfaces of samples irradiated with UV laser there are large areas of the same phase (Figs. 5 and 6). Hence it may be inferred due to heat treatment that crystallites produced in irradiated samples are of bigger size than in not irradiated samples. Therefore the glasses, investigated glasses, are most photosensitive to the excitation with ultraviolet laser.

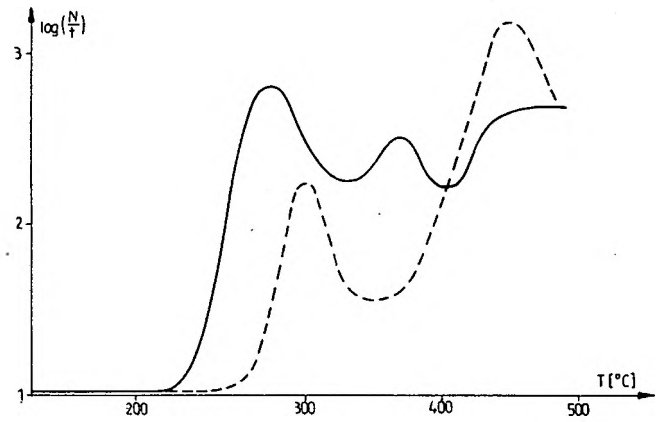

Fig. 4. TSEE curve of a glass irradiated with ultraviolet N_2 laser

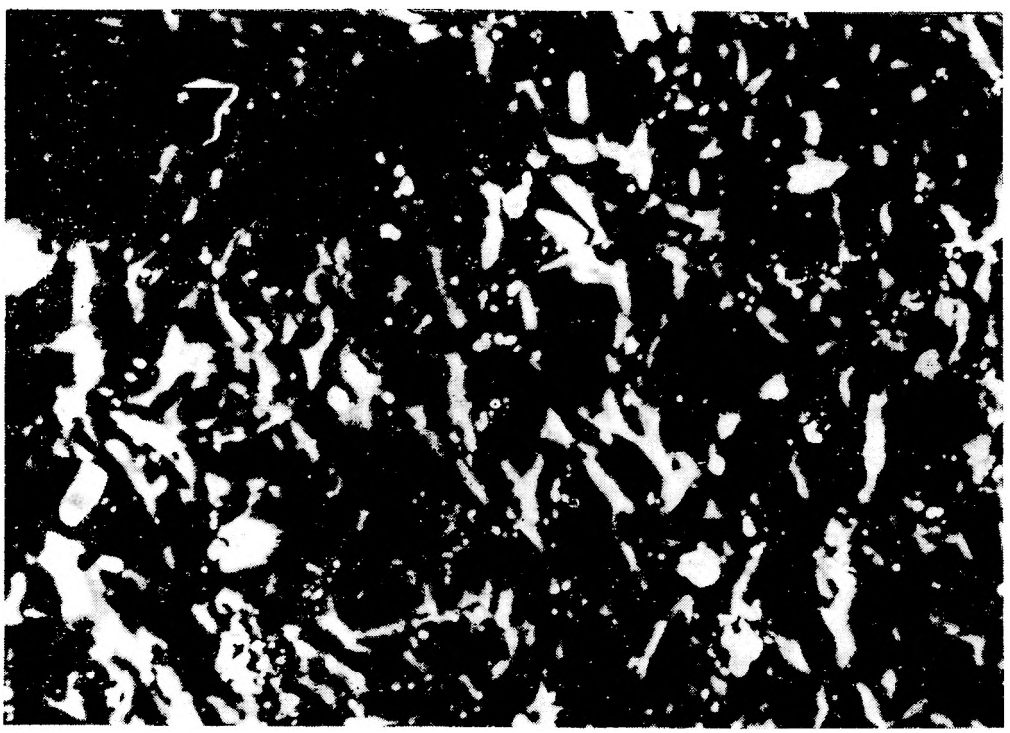

Fig. 5. Scanning electron micrograph of nonirradiated heated glass sample

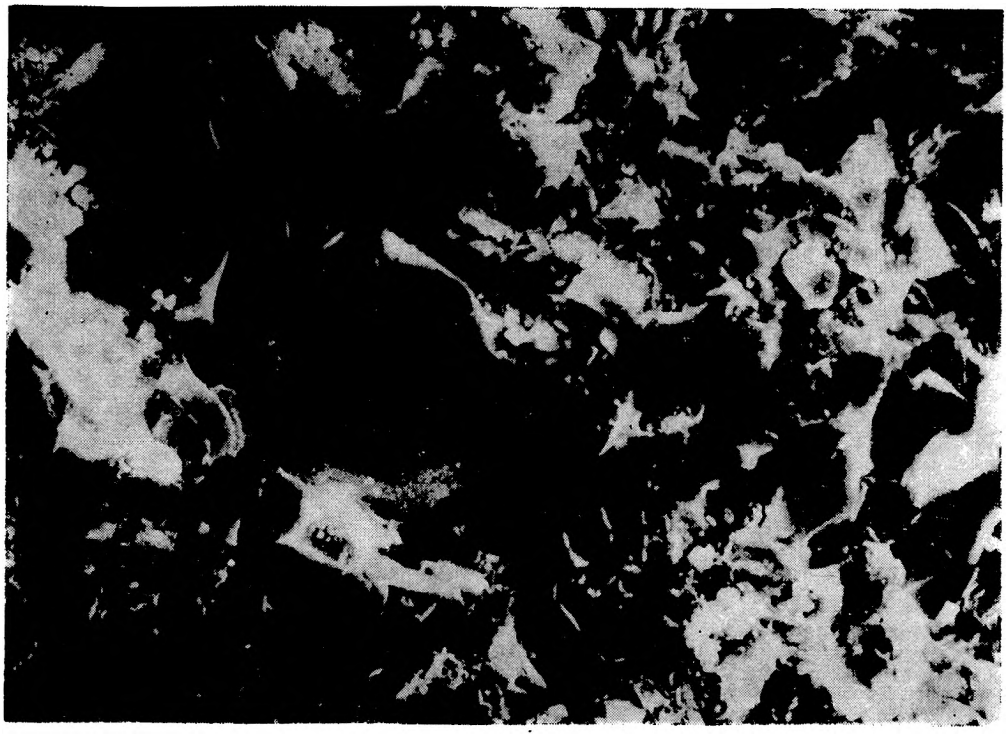

Fig. 6. Scanning electron micrograph of heated glass sample irradiated with N_2 laser

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