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Diamond luminescence was studied mainly with the two following aims: to carry out a fundamental investigation of the physical properties of diamonds and to determine the optimal conditions for luminescent sorting of diamond bearing rocks. For the first task, diamond photoluminescence was studied at liquid nitrogen temperature (77 K) at which luminescence centers are marked by characteristic zero-phonon lines and are much more informative than at room temperature (300 K). For the second task, luminescence properties should be studied at 300 K, but it was maintained that sorting under X-ray excitation is better than under UV lamps excitation and, again, the photoluminescence (PL) at 300 K was considered as unimportant property.

Moreover, new deposits have been discovered with contain diamonds without luminescence under X-ray excitation. Sometimes this portion which is unrecoverable in X-ray luminescent sorters, is big enough to warrant the development of a new sorting method. For such diamonds the UV excitation at 300 K proved to be very effective, not under UV lamps, but under powerful UV lasers [1]. In addition, in the jewels industry there is need to be able to quickly identify any particular diamond and to be able to distinguish it from the others. For example, since the appearance of diamonds living the polishing factory have no resemblance to diamonds that entered it, the opportunity exists for the polished gems to be switched for less valuable ones. The PL of diamonds at 300 K was proposed as a property that is unaffected by the cutting and polishing process and allows to discover the substitution of jewels [2, 3].

These reasons stimulated our investigation of diamond PL at 300 K. The data presented (Table and Fig. 1) are based on a representative sampling of diamonds (more than 500 stones) from different kimberlites of USSR, China and South Africa. The luminescence spectra were investigated under eximer (222, 248 and 308 nm) and dye laser (340 - 360 nm) excitations.

Table. Luminescence parameters of diamonds at 300 K

LC	Spectral-kinetic parameters				LC	Spectral-kinetic parameters			
	nm,lum	HW nm	nm,ex	decay,mcs		nm,lum	HW nm	nm,ex	decay,mcs
N3	440	50	370	0.02-0.04	S2	540	85	340	2-3, 240
A	460	100	<240	0.03,100,3000	S1	575	100	340	0.02
H3	535	70	340	0.02,7.5,7700	578	675	60	340	0.01, 200
H4	520	70	340	0.02	640	685	70	380	?
S3	535	65	340	2-3, 25	788	788	5	340	?

Determining the nature of the luminescence centers (LC) was done according to the comparative investigation of luminescence at 77 K and at 300 K on "pure type" diamonds with certain type of defects. The only luminescence center with an appreciable fine structure at 300 K is N3, while its line at 415 nm has different intensities down to disappearance (Fig. 1a). The decrease of line intensity is accompanied by an increase of the 340 nm band in the excitation spectrum. The cause may be the formation

of N3 clusters with the ensuing concentration quenching resulting from energy migration. The transfer is evidently of the emission-reabsorption type. A feature distinguishing the N3 is that its absorption is similar to its excitation and presents a mirror reflection of its PL. The line at 415 nm is present in the emission and in the absorption spectra being subjected to the concentration quenching. The process is strong in yellow diamonds with elevated N3 contents. A reabsorption at 415 nm in these diamonds is clearly seen in the spectrum with a time delay of 1 mcs, when N3 is no longer detected because of its short decay time (Fig. 1b).

The PL at 300 K enables the problems described above to be solved.

Sorting of diamonds

Luminescence is generated by two lasers with different wavenumbers - the eximer laser with the line at 222 nm which excites the A-band, and the nitrogen laser which excites mainly S3 and "578 nm" centers. A-band is present in approximately 95 % of investigated diamonds, but with the big intensity variation. Practically all the diamonds with the weak A-luminescence are characterized by strong luminescence under nitrogen laser excitation. Detection is carrying out at two spectral-kinetic selective windows - between 420 and 480 nm with time delay of 3-9 ms and between 450 and 650 nm with time delay of 1-20 mcs.

Comparative investigation yielded the following results: in 12 % of the sampling laser excitation is much more effective and may be used even for recovering diamonds from the wastes of X-ray sorters; in 85 % of the sampling laser excitation is better and allows for a higher feeding rates and recovery efficiency; in 3 % of the sampling the diamonds were not luminescent under both kinds of excitation. This sorting may be realized by the equipment demonstrated in Fig. 2.

Identification of diamonds

The combination of luminescence properties (spectra of luminescence and excitation, decay time and intensity of luminescence) at 300 K together with suitable program for data treatment allows for a reliable identification of specific diamonds and distinguishing them from others. Time-delayed spectroscopy is especially effective, because 50-70 % of diamonds have strong N3 luminescence which hinders the discrimination. After 0.001 ms delay the N3 is totally quenched and more individual bands appears (Fig. a and c).

Part of this investigation was carried out while the author worked at the All-Union Institute of Mineral Resources (Moscow, Russia). The author express deep appreciation to his former colleagues for their great help.

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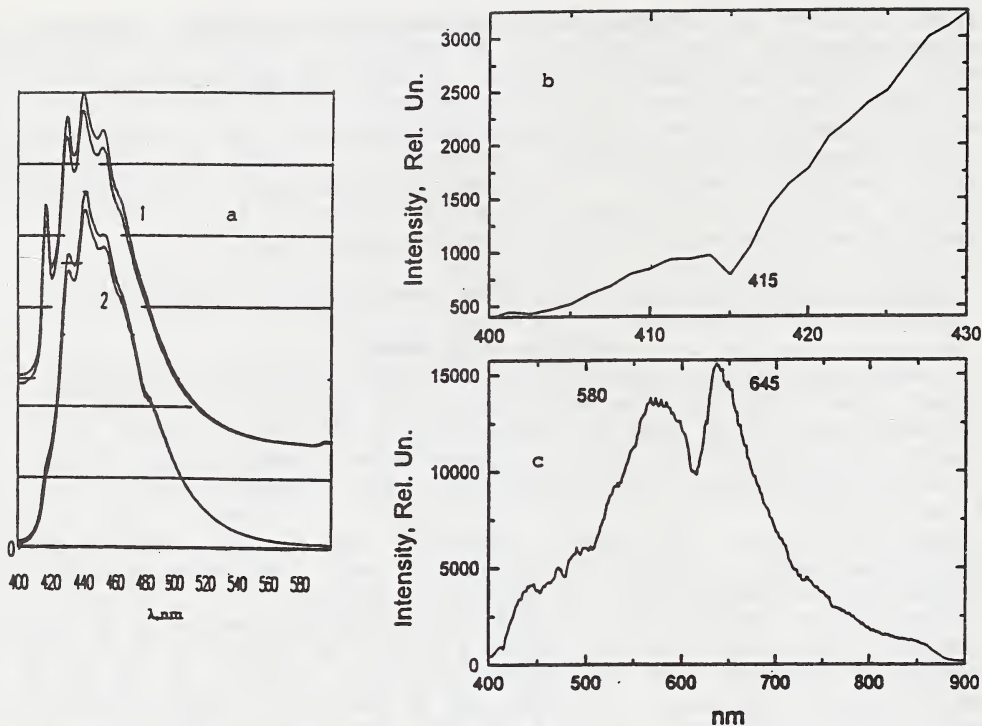
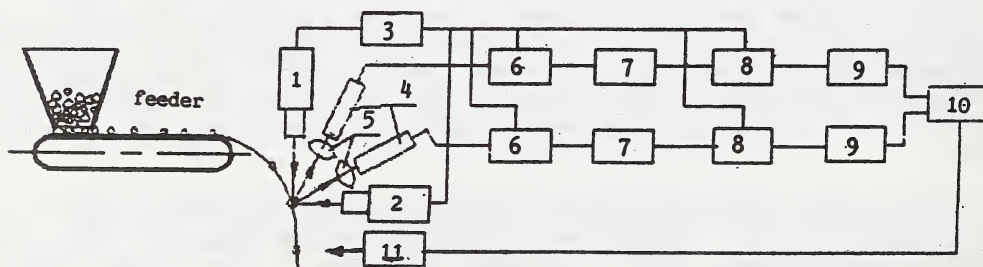


Fig. 1. Luminescence spectra of diamonds: a - of N centers (1) and clusters of N₃ centers (2); b - reabsorption at 415 nm in time-delayed spectrum; c - time-delayed spectrum (sample with N₃ clusters).



1-laser (222 nm), 2-laser (337 nm), 3-control generator, 4-monolithic spectrometer module, 5-optical system, 6-extraction range, 7-spectral ratio computation, 8-decay time computation, 9-comparator, 10-Boolean operation, 11-ejection

Fig. 2. Block-diagram of the equipment for the laseroluminescent sorting.