Pulsed Cathodeluminescence Spectrometer "CLAVI"

V.I. Solomonov, S.G. Mihailov, A.I. Lipchak,
S.A. Shunailov, M.R. Ulmaskulov, K.A. Sharypov

Institute of Electrophysics, Russian Academy of Sciences, Urals division
106 Amundsen St., Ekaterinburg, 620016, Russia, ph.: +7-343 2678779, fax: +7-343 2678794,
e-mail: plasma@iep.uran.ru

Abstract – The paper presents the brief description and characteristics of the desktop device for spectral-luminescence analysis of rigid substance, including jewels. The operation principle of the device is based on pulsed cahtodoluminescence (PCL) arised in dielectric substance by high current electron beam irradiation (mean energy 140–160 keV, pulse duration of 2 ns and maximum current about 1 kA). To the analysis the tests of dielectric substances as sand and pieces by the size up to 30 mm can be subjected. The non-destructive analysis can be carried out in an air at room temperature.

1. Introduction

Spectral luminescence analysis is one of the most express and precision methods of determination of cleanness and quality of minerals, in particular, jewels. For its practical implementation perspective is PCL raised in minerals at their irradiation by high current electron beams of nanosecond duration [1, 2]. In the given paper the description of the commercial device based on an appearance of PCL is shown.

2. Experimental Setup

The device consists of two autonomous units (Fig. 1). Firstly, it is PCL excitation unit (the size 110×200×550 mm^3). It includes the pulsed electron accelerator (1) and analytical chamber (2) for the installation of samples under an electron beam. The samples in form of sand, pieces or items with the maximum size up to 30 mm are irradiated in an air at room temperature. The second part of the spectrometer is multichannel photoreceiver (3) with overall dimensions about 120×180×280 mm^3. It includes diffractional spectroscope and multichannel photodetector docked to a personal computer (4). In the computer slot the adapter for connection of a cable from a photodetector and a cable of synchronization with the electron accelerator are installed. The flow of luminescence from samples to the photoreceiver is transmitted by the optical waveguide (5). The software allows one to control operating regime of the photoreceiver, to process and to save obtained spectra in a data base.

The electron beam accelerator itself represents the pulsed high voltage source of the RADAN series [3, 4]

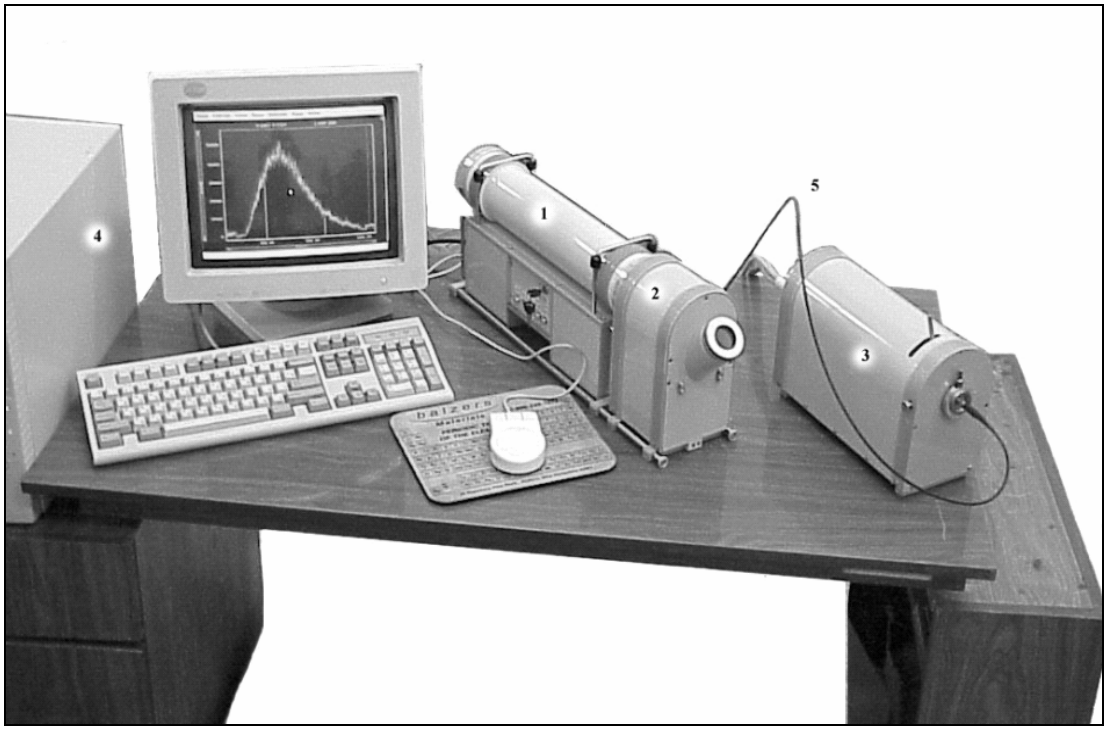

Fig. 1. Desk top PCL spectrometer "CLAVI".

named EXPERT with the sealed-off industrial electron beam tube IMA3-150 as a load (Fig. 2). Exactly this unit determines the main parameters of the setup.

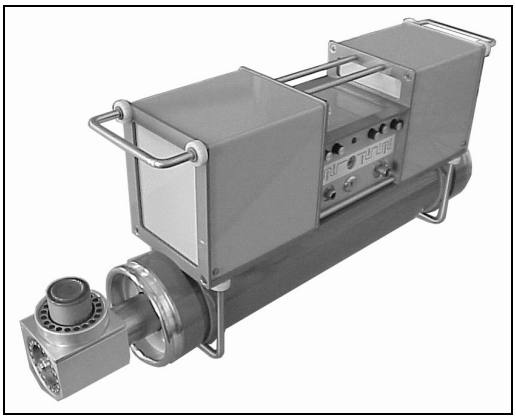

Fig. 2. RADAN-EXPERT accelerator

The accelerator forms 2 ns, about 1 kA electron beam with mean energy in the range of 140–160 keV. It is possible to synchronize the RADAN genetator and photoreceiver unit with 1 μs accuracy. A pulse repetition rate 1 Hz is restricted by safety measures (the pulsed power source permits one to operate with 10 pps repetition rate). The usual single-phase current circuit 220 V, 50 Hz is required. The device weights 8 kg (without analytical chamber). Due to low level of electromagnetic noises such compact high current accelerator can safe operate close to different sensitive equipment like a computer without any screened rooms.

Multichannel photoreceiver has the following specifications: registered spectrum range – 350–750 nm; a reverce linear dispersion of spectroscope – 23 nm/mm, apparature function – 0.6 nm. The registration time of a luminescence spectrum in all range implements less than 1 minute.

Special preparation of samples for the analysis is not required. It is possible to analyze finished stuff. After irradiation there are no irreversible changes in samples.

3. PCL Spectra

The PCL spectrum bears all common information on a mineral species of a sample and personal information on a particular sample as well. The PCL spectra of synthetic and two different natural alexandrites are given as an illustration in Fig. 3. All samples, as the representtatives of one mineral species have similar red luminescence band with the dominated R-line ($\lambda = 678.9$ nm) of an ion Cr^{3+}. The natural samples have additional blue PCL while synthetic sample has not one.

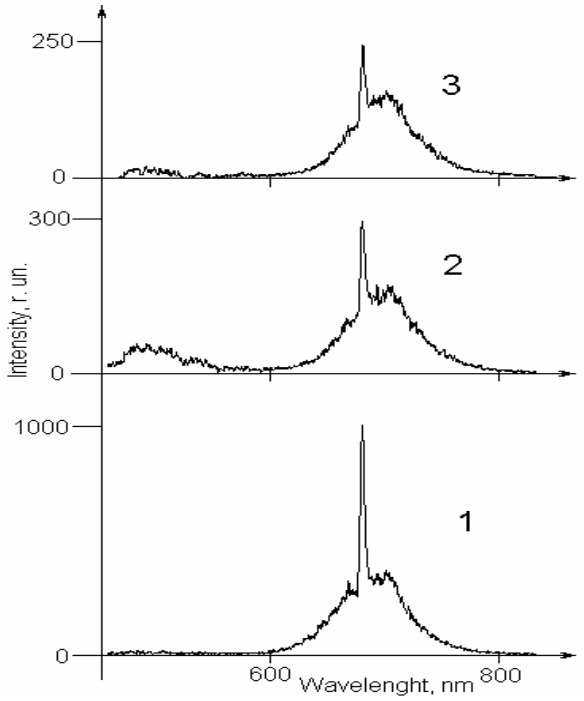

Fig. 3. PCL spectra of synthetic (1) and two different natural (2, 3) alexandrites

This device can be used in research activities in the field of optics, chemistry and physics of solid, for the solution of scientific and practical problems in geology and mineralogy.

References

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