The authors of [1] used continuous spectra, narrow-band spectra, and line spectra to show that spectral measurements of a radiation are possible by an energy analysis of the electron current caused by this radiation. When posed in this way, the problem belongs to the class of inverse problems, and its solution is not directly obtained by measurements, but only after processing experimental results on a computer.

This principle of analysis of optical spectra by photoemission is considerably simplified when a partial problem is solved, namely when a monochromatic radiation is identified [2]. In this case, the result of a measurement is obtained directly from measurements made on the basis of a prior calibration. This method is advantageous insofar as it is possible to determine a wavelength at low luminous flux values.

Such a radiation source is, for instance, a local region on the surface of a semiconductor in cathodoluminescence analysis because the electron beam scans the surface in the course of time and each semiconductor surface point which is excited by a probing electron is a source of monochromatic radiation. In the spectral analysis of the radiation of these regions with the use of a conventional monochromator, information from sections with a small surface and a low level of radiative recombination is lost.

We made photoemission cathodoluminescence studies of the inhomogeneity of the semiconductor surface composition and of layers of films of epitaxial semiconductor structures with an RÉM-200 scanning electron microscope. An FÉU-38 photomultiplier having its long-wave sensitivity limit at 1.1 μm was used as the receiver—analyzer of the radiation. A stopping potential $U_s$ was applied to the modulator of the photomultiplier; the anode signals were measured on an oscilloscope. The wavelength was determined from the amplitude changes of the video signal peaks and the corresponding values of the stopping potential.

A large aperture was obtained because, as there are no optical elements provided for monochromatization, the photomultiplier could be placed close to the surface under inspection, and its distance to the photocathode amounted to about 2 cm. This arrangement makes it possible to use for the spectral measurements luminous currents which only slightly exceed the threshold values.

By continuously changing the stopping potential, it is possible to observe the surface in cathodoluminescence rays while the spectral composition of the radiation changes continuously. In proportion to the increase in the stopping potential, the long-wave radiation disappears in the cathodoluminescence spectrum and the contrast of the image changes under constant operational conditions of the video monitor unit.
The spectral resolution depends on the dispersion of the electron current in the cathode chamber of the photomultiplier and amounts to 3—5 mV/nm. When $U_s$ is measured with an accuracy of 10 mV, a spectral resolution of 3—2 nm is obtained.

The spatial resolution is given not only by size of the probe, but also by the spectral resolution, because the contrast of the image of regions of different composition depends upon the difference of the wavelengths of the cathodoluminescence radiation. In this case, the identification of the monochromatic radiation by photoemission makes it possible to record the weak radiation from small areas of inhomogeneities since one can make optimal use of the light flux, the spectral analysis being performed by analyzing the energy of the photoelectrons.

Fig. 1. Photometric measurements on negatives of three different sections a, b, c of the image of a gallium arsenide surface at the stopping potentials 1.0, 1.1, and 1.2 V, respectively. Scale: 2.2 μm per mm.

The possibility of a qualitative visual analysis is illustrated in Fig. 1 by the photometry curves of negatives of the image of a flat gallium arsenide surface; the negatives were obtained with three stopping potentials $U_s$. The sharply increased transmission $r$ in the central part of the curves (denoted by dashed lines) at $U_s = -1.2$ V in Fig. 1a, b confirms that at these points on the surface there are inhomogeneities the emission wavelength of which is greater than that of the neighborhood, i.e., narrow-band inclusions with a size of $-10$ μm are present at these points. This conclusion is based on the fact that, when the stopping potential is changed from $-1.1$ to $-1.2$ V on these sections, the photographic contrast $K = \log (r_{\text{max}}/r_{\text{min}}) = D_{\text{max}} - D_{\text{min}}$ (with D denoting the optical density of the negative) increases from 0 to 0.16 and 0.28, whereas the contrast decreases by a factor of about 3—7 on the other characteristic sections.

One can see in Fig. 1c that on section 1 of increased optical density and a length of $-3$ μm, upon increasing the stopping potential there appear two sections (2 and 3) with a size of $-1$ μm each, and the transmissivity increases on these sections because the reaction to the radiation of greater wavelength is more strongly attenuated on both sides of the central region 1. Regions 4 and 5 are brighter than region 1 at $U_s = -1.1$ V and become denser at $U_s = -1.2$ V. Thus, there appears a fine structure of the emitting object, and this fine structure can be explained only by assuming that the emission from the various surface sections differs in its wavelength; this manifests itself also when the flux of the photoelectrons caused by this light flux is limited by the stopping potential.

This qualitative analysis can be rapidly performed by visual observation of the change of the visible contrast on image sections examined and by visual observation of the amplitude change of the characteristics of the video signal. The photomultiplier—video monitor—photographic film system must be calibrated for a qualitative analysis; the calibration must be made in the coordinates: optical density of the photographic film—stopping potential, i.e., $D = f(U_s)$ for the wavelengths selected. Measurements must be made only within the exposure range of the film.

When the quantitative analysis is based not only on the image of local microregions but on the anode signal i generated in the photomultiplier by the radiation from these regions, the determination of the composition of regions with different contrast necessitates a calibration of the photomultiplier with the aid of monochromatic light fluxes; one obtains a set