# APPLICATION OF LIGHT-EMITTING DIODES FOR ACCURATE MEASUREMENTS OF LIGHT BEAM ATTENUATION OF NATURAL AND ARTFICIAL MEDIA

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**Abstract.** The brief review of modern powerful light-emitting diodes specifications is given. The description of light attenuation meter for seawater measurements is made. Some results of investigation of phytoplankton cell suspensions and natural waters are shown.

## 1. Introduction

At present time the optical methods are frequently applied for determination of seawater suspended matter composition. These methods, based on measurements of light scattering and absorption by water media, are more fast and not such laborious as compared to traditional biological and chemical methods, but sometimes their accuracy is not sufficient. Using of auxiliary spectral information allow to raise accuracy of optical definitions [1].

Up to the recent time, the powerful arc lamps and filament bulbs were applied in the spectral optical meters as a light source. For separating the necessary spectral bands, the monochromators or the sets of narrow-band optical filters were traditionally used.

Success in creating the semiconductor light emitting source allows deviating from traditional schemes. The light flux of modern powerful ultra bright LEDs exceeds the light flux of the filament bulbs in comparable spectral intervals. Preliminary calculations have shown that using of ultra bright LED instead of filament bulb gives an advantage in the light flux at least in ten times, and in the short-wave spectrum range even in hundreds times, that is particularly important during the measurements of scattering and fluorescence.

The normalized spectra of the halogen lamp and of the standard set of LEDs of the Philips Lumileds Lighting Company are illustrated on the fig. 1 [2].

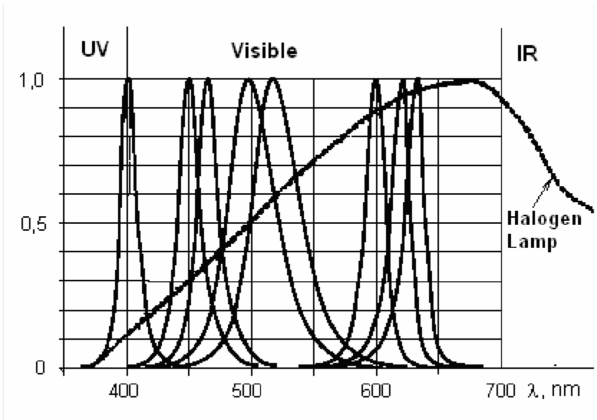


Fig. 1. The normalized spectra of the halogen lamp and the standard LED set

One can see on Fig. 1 that the LED spectral bands are distributed over the whole visible spectrum range. The spectral bands are relatively narrow (of 15 – 35 nm), and it is possible to consider the LED flux by quasi-monochromatic one. Thereby, at the time of developing the instruments for seawater in situ measurements, it is possible to abandon from using the interference filters and, accordingly, from the mechanism of their switching, that will reduce the price and simplifies the instrument design. It is also should be noticed, that the ultra-bright LED is cheaper, than the interference filter in 5 – 10 times.

The small size of LED emitting surface allows creating the light sources with a small beam divergence that is important for the measurements of angular light diffusion in the water media.

Significant LEDs advantages are the quick-responsibility, reliability, the low consumption and long life-time.

Constructive performance of the powerful LEDs is varied enough (Fig. 2). The LEDs with one, two, three and four chips on one substrate are produced massively. It is also possible to book a greater chip amount, but the price herewith will increase more than in ten times. The LED producer companies offer some additional accessories like radiators, printed circuit boards for the LED substrates, thermal adhesive tape, collecting lenses and the power supplies of acceptable prices.

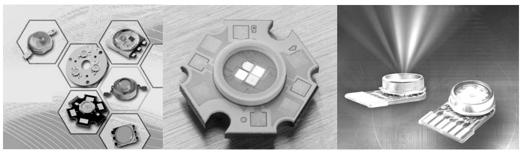

Fig. 2. Exteriors of the LED and diode assemblies [3, 4]

## 2. Spectral Beam Attenuation Meter

Taking into account the value of the modern semiconductor light sources the spectral beam attenuation meter, intended for field measurements, including ones on the small boats, was designed in the Marine Optics Department of NAS of Ukraine.

In the aim of compensation of instability of the light emitting and receiving diodes, the two-beam measuring principle was applied. Autocollimated optical scheme with a cube corner prism as a reflecting element minimizes inaccuracy of the measurements, caused by inexactnesses of a construction (design) adjustment and deformation in consequence to external pressure [5], as well as it enables undertaking the BAC measurements with different lengths of the measuring base. The cube corner prism using in the meter complicates the process of the meter calibration [6], but if the features of the meter are stable and linear, it is possible to calibrate it with the etalon water with the known optical properties. Additionally, in the case of stable linear feature, the absolute value of the BAC may be calculated by measuring at two different lengths of the measuring base, and without conducting the calibrations.

The meter includes the water temperature sensor and the sensor of hydrostatic pressure providing additional information about the vertical structure of hydrooptical fields.

The functional scheme of the meter is shown on Fig. 3. With the number 1 the beam-splitting plate is marked. The main elements of the functional scheme were divided into two channels - measuring and reference. The reference channel contains the LED, the output diaphragm, the beam-splitting plate (1), the rectangle prism, an input diaphragm, the photodiode of the reference signal, an amplifier of the reference signal. The measuring channel consists of the same LED, the output diaphragm, beam-splitting plate, the objective-window, the cube corner prism, an input diaphragm, the photodiode of the measuring signal, an amplifier of the measuring signal.

The light, coming from the LED, splits into two beams by the beam-splitting plate. Passing through the beam-splitting plate, the measuring beam, formed by objective-window into the parallel light beam, comes into investigating medium. The measuring beam passes the distance up to the cube corner prism, then reflects from it, once more gets through the measured medium in the opposite direction and finally returns into hermetic housing through the same objective-window. The medium attenuated beam inside the housing, being reflected from the beam-splitting plate, is focused to the center of the measuring diaphragm, then falling onto one of the photocathodes of the two-element photodiode. After amplification, the signal is passed to the multiplexer input of analog-to-digital converter (A/D converter) of Analog Devices Inc. microconverter ADuC814.

The reference beam is formed from that part of the LED light, which is reflected from the beam-splitting plate. By means of rectangle prism, the reference beam is turned directly to the other photocathode of the two-element photodiode.

As a light source the ultra-bright, 4 color LED of the LEDENGIN company [7] with current of 0.35 A and maxima on the wavelengths of 460 nm, 520 nm, 590 nm and 625 nm was used in the meter.

The choice of the spectral bands is caused by the following factors:

- a band of 460 nm corresponds to the blue maximum of the chlorophyll absorption;
- bands of 520 nm and 590 nm are used for revising the BAC spectrum shape;
- a band of 625 nm is important for the estimation total scattering coefficient.

In the aim of the power consumption reduction, the LEDs are turned on alternately.

For the temperature measurements the 1kOm thermistor with the time constant of 0.3s, connected into the Winstone bridge is used. The pressure is measured by the strain gauge DD2.5A. After amplification, the sensor signals also come into the microconverter to the multiplexer input.

The microconverter ADuC814 of the Analog Devices Ink. digitizes the analog signals and provide serial data output.

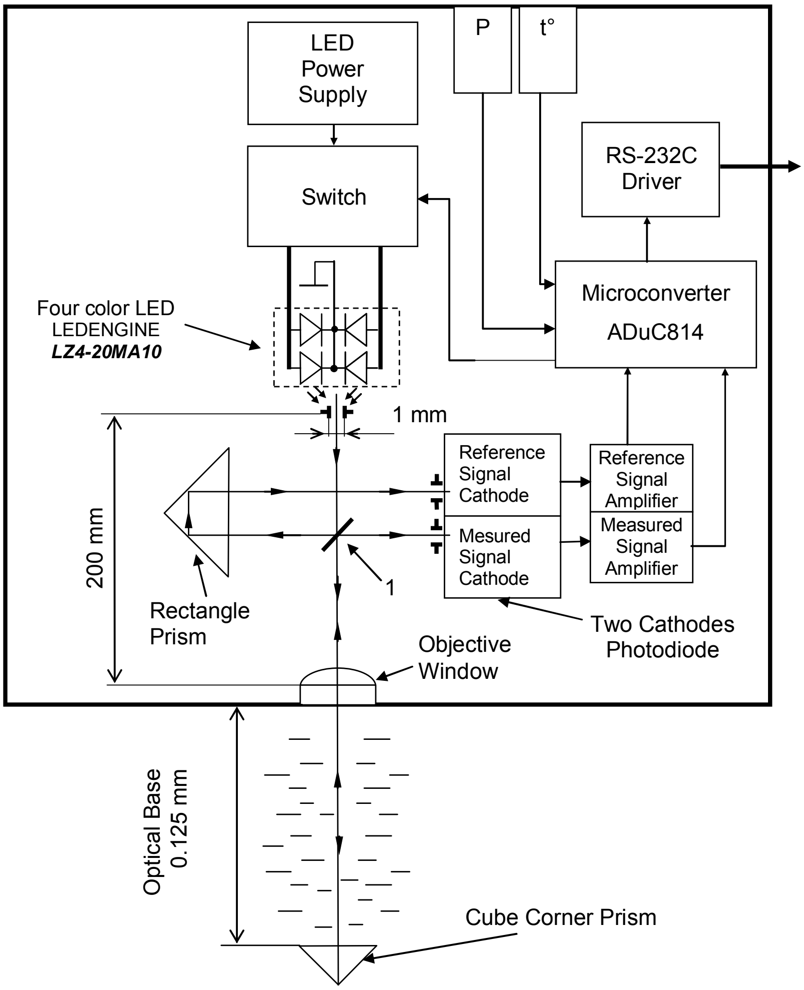


Fig. 3. The spectral attenuation meter structure scheme

Switch management for alternating LED turning on is also realized by microconverter. For data sending to the desk computer by the cable, the output signal levels of the microconverter are transformed into the standard RS-232C levels by the IC max232 of the Maxim Ink. The 4-wire cable of 150 m length realizes the connection with the desk computer at the baud rate of 1200 b/s. The main technical features of the BAC meter are given in Table 1.

Table 1 - The main technical specifications of the meter.

| | |
|---|---|
| BAC measurement range (lg) | – 0.01-1.0 $m^{-1}$; |
| BAC measurement inaccuracy (lg) | +/- 0.015 $m^{-1}$; |
| Spectral bands | – 460, 520, 590, 625 nm; |
| Optical base length | – 0.125 m; |
| Time constant of BAC measuring | < 0.5 sec; |
| Temperature measurement range | – 0 – 40; |
| Temperature measurement inaccuracy | +/- 0.2°C; |
| Time constant of temperature measuring | < 0.3 sec; |
| Max working depth | – 150 m; |
| Depth measurement inaccuracy | +/- 0.5%; |
| Connection with the on-board notebook | – 4-wire cable; |
| Sample rate | – 3 Hz; |
| Power supply | + 12 – 18 V, 0.35 A; |
| Dimensions | – Ø100 x400 mm; |
| Weight | – 3.5 kg. |

On Fig. 4 an example of spectral measurements of different waters is shown. Drinking water means the bottled drinking water from supermarket. After measurements of drinking water sample, the *Chlorella Vulgaris* solution was added to a vessel with the attenuation meter. One can see rising of attenuation, especially in blue region.

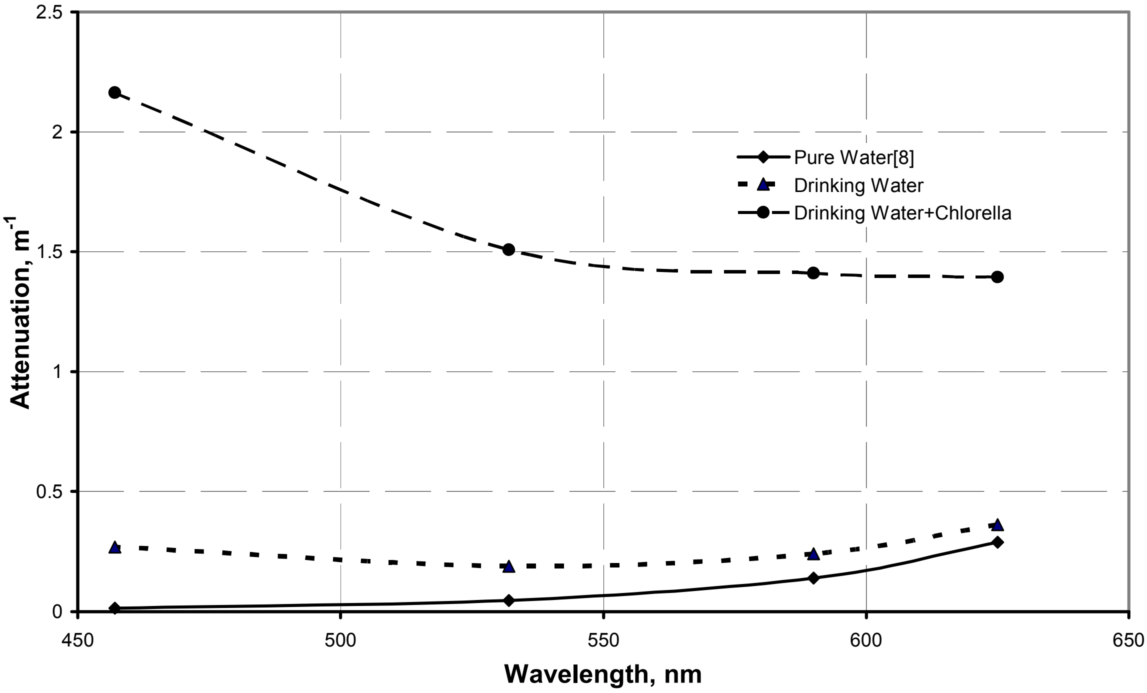


Fig. 4. An example of spectral measurements of BAC

Further accumulation of data will allow to create the informative base of signs, on which will become possible to determine a presence in water of different admixtures, that is the important task of the ecological monitoring.

## Conclusion

Using the modern semiconductor light sources in the instruments for hydrooptical studies allows creating the more economical, reliable and suitable meters, that is especially important for the investigations in the field conditions.

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