INSTRUMENTATION, PRECISION AND ACCURACY, DATA MEASUREMENT TOOLS AND SYSTEMS

DOI - 10.32743/UniTech.2021.86.5.11711

DEPENDENCE OF MATERIALS ENLIGHTENMENT ON TEMPERATURE

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ЗАВИСИМОСТЬ ПРОСВЕТЛЕНИЯ МАТЕРИАЛОВ ОТ ТЕМПЕРАТУРЫ

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ABSTRACT

We presented the calculation results for enlightenment coefficient by laser radiation plastic, organic glass and laundry soap at different temperatures. One has carried out experiments on range of temperature 0÷100 ºC. For materials enlightenment we used semiconductor laser diode ATC-C500-200 type, radiating on wavelength 668 nm. We showed that enlightenment effect influences on laundry soap better than other materials. One has revealed that in all samples at temperatures at range of 0÷40 ºC the enlightenment effect does not appear practically. At range of 40÷60 ºC the dependence of enlightenment coefficient on temperature is linear practically and when temperature is growing further from 60ºC then values of this coefficient is increasing sharply.

АННОТАЦИЯ

Представлены результаты расчетов коэффициентов просветления под действием лазерного излучения пластмассы, органического стекла и хозяйственного мыла при различных температурах. Измерения проводились при температуре 0÷100 ºC. Для просветления материалов использовали полупроводниковый лазер ATC-C500-200, излучающий на длине вольны 668 нм. Показано, что эффект просветления у хозяйственного мыла проявляется сильнее по сравнению с остальными материалами. Выявлено, что в интервале температур 0÷40 ºC эффект просветления практически не проявляется. В интервале 40÷60 ºC зависимость коэффициента просветления практически линейная, далее с увеличением температуры от 60 ºC значения коэффициентов растут существенно.

Bibliographic description: Nasirov T.Z., Xojiyev F.A., Soliyeva F.M. Dependence of materials enlightenment on temperature // Universum: технические науки : электрон. научн. журн. 2021. 5(86). URL: *https://7universum.com/ru/tech/archive/item/11711*

Keywords: saturation coefficient, enlightenment effect, plastic, organic glass, laundry soap, materials.
Ключевые слова: коэффициент просветления, эффект просветления, пластмасса, органическое стекло, хозяйственное мыло.

Introduction

Since appearing nanoobjects and deal with them physical phenomena, the essential progress in optics had been taken. We can safely said that today development this science dominates, basically, in practical application while leaving behind to study the theoretical aspects any new physical effects. The enough interest and comparative little studied aspects of modern applied optics is enlightenment effect of materials.

This effect is very interesting because of practically in any substance has a definite temperature range (or additionally some parameters) by which one begins pass visible light radiation to some extent. Other words, substance will becomes somewhat transparence. It is interesting to investigate the conditions by which the substance becomes transparency in such parameters, at which most optoelectronic devices at present is working.

For example, in paper [1] had been investigated the optical properties of insulator medium where shown that presence of nanocavities layers near the borders section "environment-vacuum" which is able to increase the system transparency in a wide range of wavelength up to 100 %. And in Ref. [2] had shown that growing possibility of values of collimated coefficient of skin transmission 20÷40 times on dependence of wavelength and decreasing diffuse reflection coefficient up to 16 % by influencing water solution of glycerin.

Analogically enlightenment possibility of insulator with Ag nanoparticles having no spherical shape had been shown in paper [3] where introduction their nanoparticles directly to enlightenment material in sub wavelength had been proposed.

Passing transverse electromagnetic wave via heterogeneous medium and appearing in some layer's soliton like wave field bursts with its essential forcing due to sharp recline of wave vector value. In Ref. [4] based exactly solvable model task had been investigated.

In paper [5] the conditions and frequency band of total absorption of electromagnetic radiation in flat layer of absorbing insulator with covered to it of two enlightenment and non-absorbing layers, one of themselves has quarter wave thickness, had been found.

The enlightenment task in classical point of view considered in Ref. [6] where it had been introduced to case of many layers magnet-insulator systems. The possibilities of transmission of electromagnetic energy via thick (several skin-layers) insulator screen constructed from high attenuation coefficient in over high frequencies in paper [7] had been investigated.

It should be also noted that in Ref. [8] the increasing method of enlightenment zone in spherical surfaces of optical parts having great curvature by covered themselves the combined layers formatted using circular aperture in vacuum equipment had been proposed. By modeling spectral characteristics of Ge sub element of three GaInP/GaAs/Ge transmitting solar elements had been shown [9] that using GaInP nuclear layer creating thin diffuse p-n junction in Ge allows increase Ge sub element photo generated current in comparison of values in case of GaAs nuclear layer.

In the present paper the analysis of investigations results carried out in usual home conditions on studying of enlightenment process of some materials has been presented. Measuring the light radiation intensity by transferring via different thicknesses we calculated values of absorbing coefficients and enlightenment ones. The light beam in experiments we obtained from semiconductor laser diode ATC-C500-200 type working at 668 nanometer wavelength.

The theoretical review

It is known, that by single photon absorbing of monochromatic radiation the enlightenment effect by this representation is described

$$\frac{dI}{dx} = -k(I)I\ . \tag{1}$$

Here I is the wave intensity in x point, $k(I)$ is the absorbing degree depending on the intensity. Its form is defined with concrete physical enlightenment mechanism and character of absorb line broadening. For example, if enlightenment effect conditioned by saturation and absorb line is broadened uniformly then

$$k(I) = \frac{k_0}{1+\alpha I}. \tag{2}$$

Here k_0 is the absorb degree which figures in Buger-Labbert law, α is the saturation coefficient. Its physical meaning we shell find substituting condition

$$\alpha = \lim_{k_0\to\infty} \frac{x}{I},$$

That is the angle coefficient of linear dependence for x and I by $k_0 \to \infty$. After integrating equation (1) with substituting representation (2) we obtain

$$x = -\frac{1}{k_0}\left(\ln\frac{I}{I_p} + \alpha I\right). \tag{3}$$

Here I_p is the integrating constant. Its value we find easily substituting x=0

$$I_p = I_0 \exp(\alpha I_0)\,, \tag{4}$$

I_0 is the radiation intensity in entering moment to sample.

Further substituting representation (4) to one (3) we rewrite it as

$$x = -\frac{1}{k_0}\left[\ln\frac{I(x)}{I_0} + \alpha\left(I(x) - I_0\right)\right]. \qquad (5)$$

As we see from representation (5), that the enlightenment investigate task of concrete sample leads to definition the k_0 and α constants values. For convenience we will introduce following remarks

$$A(I) = -\ln\frac{I(x)}{I_0}; \quad B(I) = -\left(I(x) - I_0\right). \qquad (6)$$

In result from representation (5) we will obtain the algebraic equation for two unknowns parameters, k_0 and α

$$x = \frac{1}{k_0}\left[A(I) + \alpha B(I)\right]. \qquad (7)$$

Considering parameters values k_0 and α are constant and also taking into account that intensity we will measure by different x values equation (7) can be rewritten as

$$x_i = \frac{1}{k_0}\left[A_i + \alpha B_i\right],\ i = 1,...N. \qquad (8)$$

Here N is the measures quantity.

Onwards, because of in different measures the calculated values of k_o and α parameters can be differ from each other we will take the following procedures.

The first, in all calculations of k_{oi} and α_i parameters values we will calculate ones using x_i and I_i values of i-th and previous (i-1)-th measurements. In this case, after solving equation (8) regarding k_0 and α parameters we will obtain following representations

$$\alpha_i = \frac{x_i A_{i-1} - x_{i-1} A_i}{x_{i-1} B_i - x_i B_{i-1}}; \quad k_{0i} = \frac{A_{i-1} B_i - A_i B_{i-1}}{x_{i-1} B_i - x_i B_{i-1}};$$
$$i = 2,...,11. \qquad (9)$$

The second, in each measurement of k_{oi} and α_i parameters values we will calculate separately and then their required values will find by averaging.

Experimental equipment

In order to obtain quantitative comparative picture as the samples we have prepared on 10 materials of white plastic, white organic glass and white laundry soap having rectangular parallelepiped shapes with wideness and height dimensions 2×2 centimeters and lengths from 1 up to 10 centimeters in normal thermodynamic conditions. The sample length in experiments we chose as x-axis.

The sequential structure scheme of experimental equipment in Figure 1 has been presented. In order both to exclude the ingress of external lighting to sample and radiation dissipation to environment we investigations have carried out in the darkened chamber. In that for measuring intensity entering to sample radiation from laser diode between radiation source and investigating sample we established the first luxmeter. After that we have measured the intensity this luxmeter for a definite period is removed. The light can be dissipated partly when it is passing by sample. Namely because of in exit of sample the collecting lens have been established. On its focus length the second luxmeter for measuring intensity of exit radiation has been established.

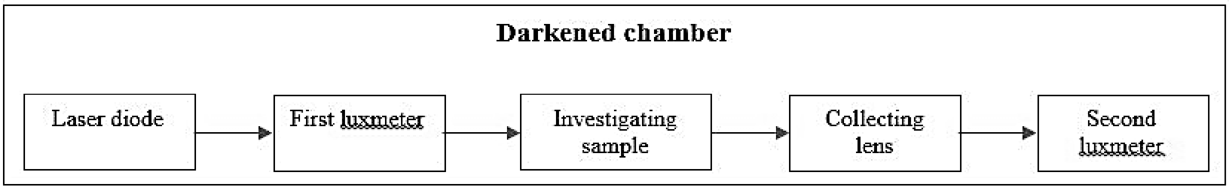

Figure 1. The sequential structure scheme of experimental equipment

For establishing saving and measuring the temperature values in the darkened chamber we used the air heater, spiral oven and thermometer.

Changing consistently the samples by increasing their length from zero up to 10 centimeters for each of materials and supporting them approximately 2-3 seconds we have measured for each case the corresponding x_i and I_i values. Using measured results we calculated values for A_i and B_i parameters with which one defined k_{0i} and α_i parameters values and finally their averaged values and absolute errors. These results in Table 1 have been presented.

As seen in Table that light passes via laundry soap better in comparison of plastic and organic glass. As to the absorb coefficient that its value for plastic greater than ones for organic glass and laundry soap.

Table 1.

Numerical results for α and k_o parameters obtained on experimental data

i	x_i, cm	I_i, lux	A_i	B_i, lux	α_i, cm/lux	k_{0i}, cm^{-1}	$\bar{\alpha}$, cm/lux	$\bar{k}_0$, cm^{-1}	$\overline{\Delta\alpha}$, cm/lux	$\overline{\Delta k_0}$, cm^{-1}
Measurements with white plastic										
1	0	7976	0.00000	0						
2	1	6463	0,21034	1513	0,000172	4,447468	$1{,}3757\times10^{-4}$	3,667	$4{,}29\times10^{-6}$	$9{,}87\times10^{-17}$
3	2	5102	0,44680	2874	-0,000086	1,360769				
4	3	4314	0,61457	3662	0,000254	4,742606				
5	4	3319	0,87677	4657	0,000248	4,375247				
6	5	2467	1,17343	5509	0,000236	4,074407				
7	6	1772	1,50433	6204	0,000248	3,9977				
8	7	1223	1,87513	6753	-0,000044	2,883115				
9	8	965	2,11206	7011	0,000031	3,288273				
10	9	727	2,39527	7249	0,000179	3,83763				
11	10	502	2,76559	7474	0,000172	4,447468				
Measurements with white organic glass										
1	0	7976	0.00000	0						
2	1	6667	0,179267	1309	-0,000990	-10,87361	$1{,}3968\times10^{-4}$	2,767	$7{,}55\times10^{-5}$	$1{,}48\times10^{-16}$
3	2	5309	0,407034	2667	-0,000076	1,419208				
4	3	4511	0,569918	3465	0,000032	2,656637				
5	4	3691	0,77054	4285	0,000622	7,487976				
6	5	2771	1,057229	5205	0,000958	8,676197				
7	6	1902	1,433531	6074	0,000608	5,694770				
8	7	1223	1,87513	6753	-0,000044	2,883115				
9	8	965	2,112064	7011	0,000025	3,274243				
10	9	729	2,392519	7247	0,000121	3,687466				
11	10	520	2,730364	7456	-0,000990	-10,87361				
Measurements with white laundry soap										
1	0	7976	0.00000	0						
2	1	6675	0,178068	1301	-0,000840	-8,950530	$3{,}1185\times10^{-5}$	2,292	$1{,}63\times10^{-5}$	$5{,}40\times10^{-16}$
3	2	5315	0,405904	2661	0,000017	2,481600				
4	3	4314	0,614571	3662	0,000254	4,742606				
5	4	3319	0,876773	4657	0,000281	4,619920				
6	5	2452	1,179533	5524	0,000209	3,912386				
7	6	1772	1,504328	6204	0,000248	3,997700				
8	7	1223	1,875130	6753	-0,000055	2,839700				
9	8	973	2,103808	7003	0,000004	3,199031				
10	9	746	2,369467	7230	0,000165	3,789940				
11	10	521	2,728442	7455	-0,000840	-8,950530				

Numerical results and their discussion

At the same time values for enlightenment coefficients which more relevant to enlightenment effect that its values obtained for plastic and organic glass are similar practically and for laundry soap in comparison of these materials is approximately 4 times less. It follows that the intensity dependence of the passing via itself light on thickness for laundry soap less in comparison of plastic and organic glass.

Further temperature in experiments we varied in range of 0÷100 ºC with 10 ºC interval. Taking into account of melting possibility of samples by temperature influence in the darkened chamber we put them to quarts cuvettes.

Dependence of enlightenment coefficients values of samples on the temperature obtained based on experimental results have been presented in Figure 2, where solid line corresponds to plastic, dashed and dotted lines correspond to organic glass and laundry soap, correspondingly.

As seen in this Figure in all samples at temperatures range 0÷40ºC the enlightenment effect does not appear practically. At 40÷60ºC temperatures range dependence of α coefficient on the temperature is linear practically and beginning from 60ºC its values is growing sharply.

It should be also noted that from studied three samples the enlightenment effect in case of laundry soap appears better in comparison of other two kind of materials.

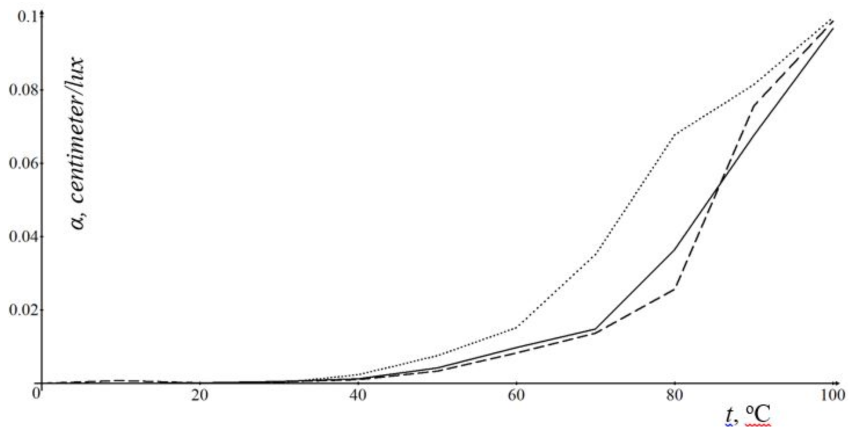

Figure 2. Dependence of enlightenment coefficients values of samples on the temperature obtained based on experimental results: solid line corresponds to plastic, dashed and dotted lines correspond to organic glass and laundry soap, correspondingly

Conclusion

Thus, based on analysis of results obtained from investigations of enlightenment effect of white plastic, organic glass and laundry soap at temperatures range 0÷100ºC we can conclude the following.

The values obtained for enlightenment coefficients which more relevant to enlightenment effect that its values obtained for plastic and organic glass are similar practically and for laundry soap in comparison of these materials is approximately 4 times less. It follows that the intensity dependence of the passing via itself light on thickness for laundry soap less in comparison of plastic and organic glass.

For all chosen for studying materials at temperatures range 0÷40 ºC the enlightenment effect does not appear practically. At 40÷60 ºC temperatures range dependence of α coefficient on the temperature is linear practically and beginning from 60 ºC its values is growing sharply.

It should be also noted that from studied three samples the enlightenment effect in case of laundry soap appears better in comparison of other two kind of materials.

Finally, from results presented on Table we can obtain the true values ranges estimations for α parameters of plastic, organic glass and laundry soap for normal thermodynamic conditions

$$\alpha_{\rm pl} = (0{,}9467 \div 1{,}8047) \times 10^{-4} \text{ centimeter/lux;}$$

$$\alpha_{\rm og} = (0{,}6418 \div 2{,}1518) \times 10^{-4} \text{ centimeter/lux;}$$

$$\alpha_{\rm ls} = (1{,}4885 \div 4{,}7485) \times 10^{-5} \text{ centimeter/lux.}$$

Acknowledgment
N.T.Z. thanks the grant entitled Uzb-Ind-2021-96 for financial support of these investigations.

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