

“RESEARCH OF PHYSICAL PROPERTIES OF NATURAL SEMICONDUCTOR FIBERS”

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ABSTRACT:

It was revealed that the photoconductivity spectra of various varieties of cotton fibers doped with iodine are different from each other. It was found that the electrical conductivity of cotton fibers undoped and doped with iodine and KMnO_4 increases exponentially with increasing temperature. Infrared quenching and long-term relaxation of the photoconductivity of cotton fibers doped with iodine were detected. For the first time, it was found that with small doses of UV irradiation of silkworm green, the quality of silk fibers improves, and with large doses it worsens.

Keywords:

Cotton and silk fibers, alloying, photoconductivity, electrical conductivity, unwinding of cocoons, breaking strength of fibers.

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INTRODUCTION

Recently, research has been successfully conducted in the field of physics of natural fibers. This, in particular, is due to the fact that semiconductor properties are detected in cotton and silk fibers (CF and SF) [1]. Natural polymers such as cotton and silk fibers have structures of successively alternating crystalline and amorphous regions. The electrophysical and optical properties of CF and SF are very sensitive to external influences (temperature, alloying, uniaxial pressure, humidity, light) and can easily be modified to obtain materials with desired properties. Based on cotton fibers, thermistors, photosensitive materials, humidity sensors [2], photodiodes [3] and field effect transistors [4] were created. When treating the surface of CF, it was revealed that the properties are mainly determined by grade and cuticle of the surface part of CF with a thickness of the order of $1\ \mu\text{m}$ with a conditional fiber diameter of $10\text{--}15\ \mu\text{m}$ [5]. Photoluminescence [6] and photoconductivity (PC) in the intrinsic absorption region of CFs doped with iodine were also found in CF [7]. Also, infrared quenching and long-term relaxation of photoconductivity in due to the adherence of

charge carriers to the deep levels formed upon the introduction of iodine into an CF were found [8–10].

It follows from the foregoing that a new scientific direction “Physics of Natural Semiconductor Physics and New Original Scientific Results have been developed at present.

However, despite the successes achieved, there are still many unresolved issues, including the physics of these phenomena is not fully understood. Therefore, expanding the circle of research in this scientific direction will reveal ways to regulate the electrophysical and optical characteristics of natural polymeric nanostructured semiconductor materials and will open up wide possibilities for creating new discrete semiconductor elements and electronic equipment on their basis.

This paper presents new research results of CF and SF.

MATERIALS AND METHODS

For research, samples were made using the following technology. The object of the study was cotton and silk fibers. In order to dope CF with iodine, first seed CF was thoroughly combed with

a fine comb (with a spike period of 0.5 mm), then seeds were cut from the side. Then, CF was impregnated in 5 or 10% alcohol solution of iodine. Then iodine diffusion was carried out at $t = 60-90^{\circ}\text{C}$ for 6-10 hours. Further, in order to create ohmic contacts, an electrically conductive adhesive based on graphite and liquid glass was developed. The crushed fine-grained graphite was moved with liquid glass to a thick state. After that, such an electrically conductive adhesive ($R = 300\ \Omega\text{m}$ with a thickness of $20\ \mu\text{m}$ and a length of 1 cm) was applied to the end sides of the HV and SH. This made it possible to obtain reproducible measurement results. Note that in parallel laid fibers are 2000-7000 pieces. The length of the sample was 5 mm. Electric currents were measured using a DMM 6500 KIETHLEY multimeter. The current-voltage characteristics of the fabricated samples in the forward and reverse directions are linear. Measurements showed that after doping with IV iodine, the samples had n-type conductivity. Note that the increase in the number of fibers is associated with the limitation of the measurement of small current values of measuring instruments.

Ligature KMnO_4 was dissolved in distilled water. We prepared a 2% aqueous solution of

KMnO₄. This solution was applied to the surface of the CF, after which they were dried for one hour at room temperature, then diffusion was carried out at 60-100⁰C for 6-10 hours.

To determine the fracture time of natural fibers, samples were prepared as follows. First, a fiber grade is selected. One fiber comes off the seeds (if it is CF) and washed in distilled water at 100⁰ C. Then, on both sides of the fiber, it is smeared with liquid glass and glued to paper cardboard with a thickness of 0.5 mm with a hole. Then at room temperature it is kept for 10 hours.

Temperature dependences of electrical conductivity were measured in the temperature range 0-100°C. The temperature of the sample was measured with a calibrated copper-constantan thermocouple.

In order to investigate the physical properties of the joint SF, an installation for unwinding cocoons has been created, which allows unwinding single joint SF without breaking up to 1200 m. The layout of the installation for unwinding cocoons is shown in Fig. 1. After unwinding, the welds were washed 3-5 times in distilled water at a temperature of 75°C. The remaining procedures for the preparation of CF samples are similar to the technology used for CF.

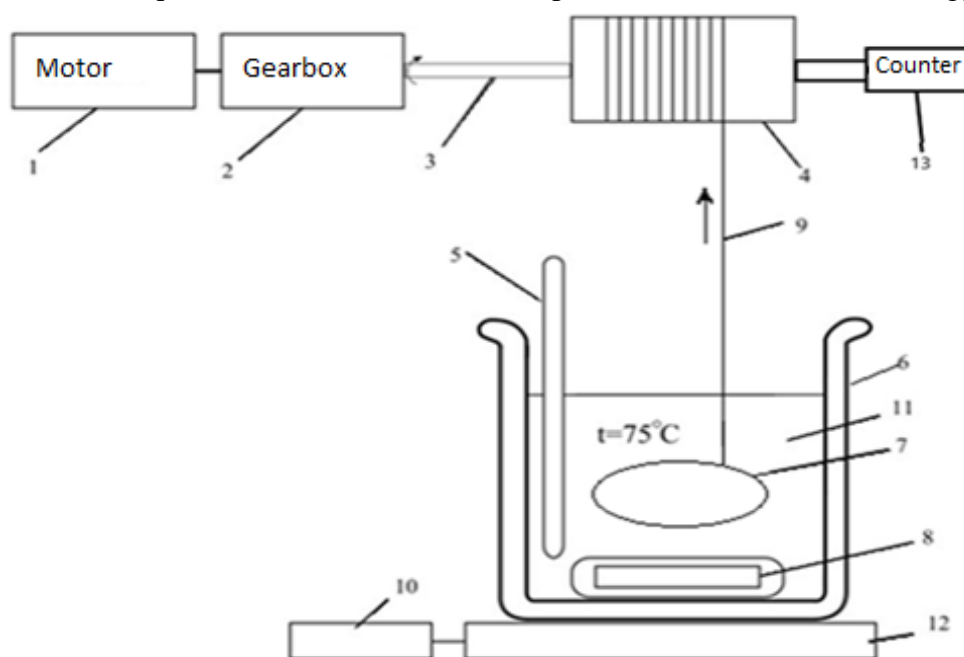


Figure 1. Installation for unwinding cocoons

1-motor, 2-gearbox, 3-rod, 4-wrap foam board, 5-thermometer, 6-glass beaker, 7-cocoon, 8-glass insulated metal plastic, 9-SF, 10-remote control water temperature, 11 -distilled water, 12-magnet and stove, 13-meter for measuring the number of motor images.

To determine the rupture time under uniaxial mechanical stress, a setup was created that allows to determine the rupture time from the applied load; the installation diagram is shown in Fig. 2. The fabricated sample is mounted to the linkage

system. Then the load is applied and at the same time the stopwatch starts. After a certain time, the sample is torn. At this moment, an electric bell rings and the measurement stops. Thus, we determine the time to break the fiber, when a certain load is applied.

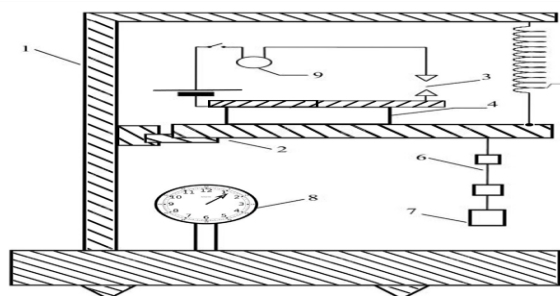


Figure 2. Installation for determining the time of rupture of the fiber under mechanical stress.

1-tripod, 2-lever, 3-contacts, 4-insulator, 5-spring, 6-test specimen (natural fiber), 7-mounts (applied load), 8-stopwatch, 9-call signaling fiber break

RESULTS AND DISCUSSION

It follows from the experiments that, under the same initial conditions, the spectra of the PC of various CF grades doped with iodine are different from each other. This can be explained by the fact that the upper shell - cuticle CF depends on their grade and they appear in the spectra of PC.

The spectra of PC of various types of CFs doped with iodine are shown in Fig. 3, measured at a temperature of $T = 300\text{K}$. PC spectra were

measured using an IRM-1 monochromator with a NaCl prism. The slit width was 0.01 mm.

The experimental fact that iodine in various grades creates deep levels of the AF spectra that differ from each other can be used to identify cotton fiber varieties. Experiments show that the administration of iodine in various varieties of CF produces various deep levels. The knowledge of the deep level ionization energy is given in table 1.

№	CF grade	Ionization energies GU, Et	
		in the upper half E_g	in the lower half E_g
1	175F<J>	$E_c - 0,8 \text{ eV}$	-
2	Gulbahor<J>	$E_c - 0,67 \text{ eV}$	$E_v + 0,8 \text{ eV}$
3	ATM-1	$E_c - 0,36 \text{ eV}$ $E_c - 0,78 \text{ eV}$	- -
4	Khazina <J>	$E_c - 0,42 \text{ eV}$	$E_v + 1,5 \text{ eV}$
5	Golib<J>	$E_c - 0,78 \text{ eV}$	-
6	Dyor <J>	$E_c - 0,35$ $E_c - 1,00 \text{ eV}$	$E_v + 0,5 \text{ eV}$ -

Table 1. Ionization energies of PGs formed upon the introduction of iodine in the forbidden zone of chemical substances ($E_g = 3.2 \text{ eV}$)

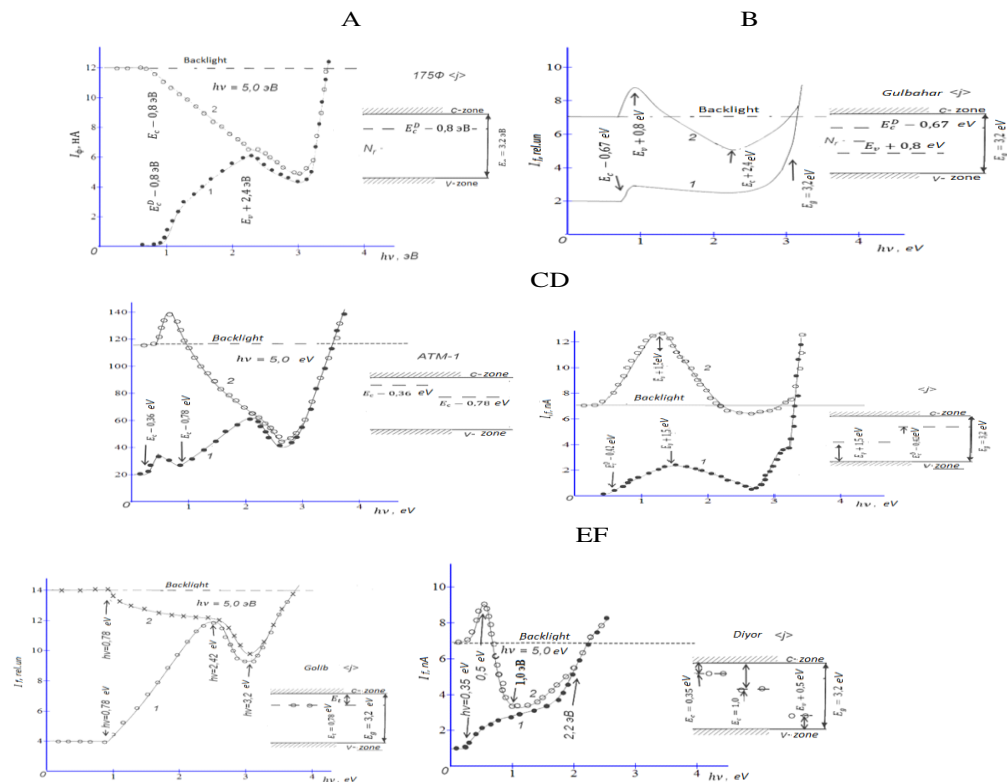


Figure 3. Spectra of various types of CFs doped with iodine.

A - 175F <J>, B - Gulbahar<J>, C - ATM-1 <J>, D - Khazina<J>,

E - Golib<J>, F - Dyer <J>. Curves 1,2 without and with constant illumination with light with $h\nu \geq$ Eg, respectively

It has been established that the electrical conductivity of the CF of grades 175F, Gulbahor, and ATM-1 undoped and doped with iodine and KMnO_4 increases exponentially with a certain

thermal ionization energy with increasing temperature. Figure 4 shows the temperature dependences of the electrical conductivity of various CF grades doped with iodine and KMnO_4

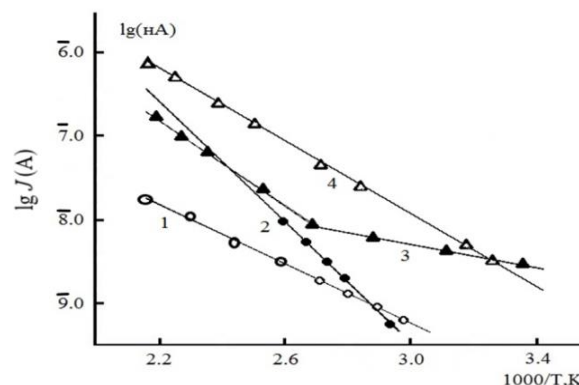


Figure 4. Temperature dependences of electric current passing through various varieties of cold water. 1-175F <J>, - Gulbahar<J>, 3- ATM-1 <J>, 4-ATM-1 <KMnO₄>

It was established that, after doping with CFs, the ionization energy of deep levels changed, which is apparently connected with the interaction of the structure of CFs with iodine.

The photoconductivity (PC) of various types of CFs doped with iodine was studied. It was revealed that when a sample is illuminated with light with $h\nu = 5.0$ eV, the photocurrent increases exponentially with time. The ratio of the

photocurrent to the dark current is equal to $I_f / I_T = 22-100$. This allows you to create photodetectors operating in the UV region of the spectrum. In combined lighting, IR quenching of photoconductivity was found in all varieties of HV. IR extinction FP is explained by the recharging of deep levels in combined lighting. After illumination of the sample with light with $h\nu \geq E_g$, (E_g is the band gap), long-term relaxation of the PC after turning off the light is revealed. With an increase in the intensity of its own backlight, an increase in PC was detected. This is due to a change in the degree of filling of a deep level of iodine in the forbidden zone of CF.

The dependence of the breaking strength of single silk fibers on the time of UV ($h\nu = 5.0$ eV) irradiation of silkworm green was determined (Fig. 5.).

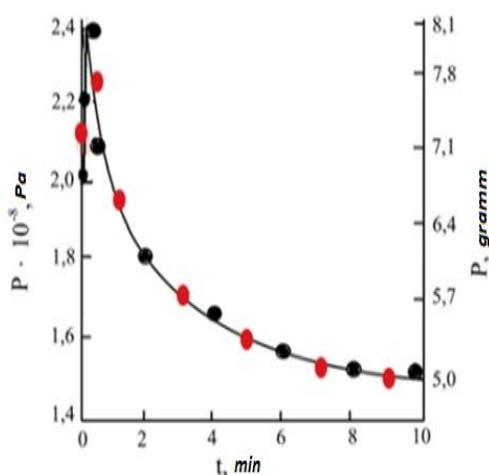


Figure 5. The dependence of the tensile strength of single silk fibers on the time of UV irradiation of silkworm green ($h = 5.0$ eV). The left scale is in units of Pa, the right one is in grams applied to single seam. $T = 300$ K.

It was revealed that at low radiation doses, the tensile strength increases, and then decreases 1.6 times. This, apparently, is due to the effect of UV light on the surface of the gray worsening the growth and development of the silkworm caterpillar. Note that a low dose of radiation ($t < 0.5$ min.) Improves the quality of silk fibers.

CONCLUSIONS

A technology has been developed for doping cotton and silk fibers with an admixture of iodine and $KMnO_4$. An installation has been created for unwinding cocoons to unwind single silk fibers without breaking up to 1200 meters. A setup has been created for determining the time of rupture under uniaxial mechanical stress of single natural fibers. It has been established that the same initial conditions the photoconductivity spectra of different varieties of cotton fibers doped with iodine are different from each other. This is due to the interaction of iodine with the surface - cuticles, which have different properties depending on the varieties of cotton fibers. This can be used to identify varieties of cotton fibers. It has been established that the electrical conductivity of unalloyed and doped with iodine, $KMnO_4$ of various types of CF increases with increasing temperature exponentially. It was revealed that upon doping with CFs, the ionization energies of deep levels changed, which is associated with the interaction of the structure of CFs with iodine. IR quenching and long-term relaxation of phase transitions after illumination of CF<J>were detected. IR extinction of PC is explained by recharging of deep levels under combined lighting.

For the first time, the dependence of the tensile strength of single silk fibers on the time of UV irradiation of silkworms was studied. It was revealed that at low doses of radiation improves the quality of silk fibers.

REFERENCES

- [1] A.T. Mamadalimov, P.K. Khabibullaev, M. Shermatov. Some problems of modifications to the physical properties of cotton fibers // UVJ. Volume 1, No.6, 465-479, (1999)[in Uzbekistan]
- [2] G.Akhmetzhanov, D.G. Akhmedzhanov, S.A. Zakirov, A.T. Mamadalimov G.I. Mukhamedov, F.A. Mukhtarova, Zh.Zh. Khamdamov, N.K. Khakimova. Electronic moisture meter. Agency for Intellectual

- Property of the Republic of Uzbekistan
OFFICIAL BULLETIN 7 (135) (21) IAP
2011 0019 (51) 8 G 01 N 26/22 Tashkent
2012 26 p. [in Uzbekistan]
- [3] A.S. Zakirov, Sh.U. Yuldashev, H.D.Cho, J.C. Lee, T.W. Kang, and A.T. Mamadalimov. Organic photodiodes on the base of cotton fibers / polymer composite// Journal of applied physics 110, 114522 (2011). 114522-1-114522-6. [USA]
- [4] Giorgio Mattana, PieroCosseddu, Beatrice Fraboni, George G. Malliaras, Juan P. Hinestroza, Annalisa Bonfiglio. Organic electronics on natural cotton fibers. Organic electronics 12 (2011) 2033-2039. [USA]
- [5] A.T. Mamadalimov, B.E. Turaev, T.T. Turgunov, T.A. Usmanov. Investigation of the effect of surface treatment of cotton fibers on their electrical properties. Reports of the Academy of Sciences of the Republic of Uzbekistan 2004 No. 3, p. 48-52.
- [6] A.S. Zakirov, Sh.U. Yuldashev, H.J. Wang, H.D.Cho, T.W. Kang, J.J.Khamdamov, A.T. Mamadalimov. Photoluminescence study of the surface modified and MEH-PPV coated cotton fibers. Journal of Luminescence 131 (2011) 301-305.
- [7] A.T. Mamadalimov, B.L. Oksegendler, Sh.O. Otazhynov, B.E. Turaev, T.A.Usmanov, N.K. Khakimova, and Zh.A. Kadirov. Features of the Photoconductivity of Iodine-Doped Cotton Fibers Illuminated in the Fundamental Absorption Range. Technical Physics Letters, 2002. Vol. 28, No. 7, pp. 581-583 [in Russian]
- [8] B.E. Turaev, E.S. Khuzhakulov, A.T. Mamadalimov. The study of the photovoltaic properties of cotton fibers of the Golib variety doped with iodine. Reports of the Academy of Sciences of the Republic of Uzbekistan of 2002 No. 5, pp. 18-20. [in Uzbekistan]
- [9] A.T. Mamadalimov. Photoelectric phenomena in semiconductors. Toshkent, NUUz, 2003, - 102s. [in Uzbekistan]
- [10] A.S. Zakirov, Sh.U. Yuldashev, H.J. Wang, J.C. Lee, T.W. Kang, A.T. Mamadalimov. "Study on electrical transport and photoconductivity in iodine-doped cellulose fibers." J Mater Sci (2011), Vol. 46, pp. 896-901.