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ScienceDirect

Energy Procedia 157 (2019) 626–634

Energy Procedia

www.elsevier.com/locate/procedia

Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES18, 19–21 September 2018, Athens, Greece

Evaluation of the optical properties for thick films of epoxy-diamond paste blend prepared by the casting method

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Abstract

Diamond paste is used in many various fields due to its distinctive and unique optical properties. In this study, the diamond paste content at different concentrations (0.15, 0.35, 0.55 and 0.75 wt. %) with epoxy resins was used to fabricate the polymer blend. Thick films were prepared of polymer blend by casting method; deposit them on thin plastic substrates. The effects of polymeric blends were studied carefully investigated on the optical properties of the blends through a variation in the concentration of additions of diamond paste. The thick films study results revealed that additive of diamond paste led to a structure improvement of the polymer blend and then improve optical properties. The optical properties of the blends were characterized by a clear effect of the additions on the absorption coefficient of the polymer blends. The optimal value for diamond paste content concentration that maximize the absorption coefficient were x = 0.55 where the absorption coefficient was at this content (4.2×10^6 cm^{-1}). Also, it has been observed direct transport allowed occurred in thick polymer films and the permissible direct energy gap was 3.1ev - 3.7ev, respectively.

Keywords: Diamond paste, optical properties, polymer blends, absorption coefficient.

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10.1016/j.egypro.2018.11.228

1. Introduction

Over in recent few decades, polymer blends garnered much interest to address more of the issues and widely used especially related to economic and modern commercial fields. There are several types - or modalities - of polymer synthesis procedures such as the liquid state method and the reaction method, each of which uses different technologies and techniques [1]. Polymeric blends preparation involves the reconstructs all the individual polymers into polymeric blends of highly dependent on the miscibility of polymers. The purpose of polymeric blends synthesis is to obtain new properties that cannot be found in individual polymers, as well as to get good optical properties [2]. Many properties of polymer blends are the object of numerous research studies especially related optical properties [2-5]. Optical properties of polymer blends films make them perfect for many applications in different life fields, especially related to such as technological display devices and others [6]. The optical behavior of the materials is closely related to the composition of the energy levels, which in turn are related to the crystalline structure of the material and thus to the general properties of that material. The optical properties provide important information for the study of materials and their placement within the appropriate application. To understand these relationships sufficiently, it is necessary to study the optical properties. As a result, there are many experimental studies on detailed optical properties to characterization of different polymeric blends from different materials [4-6]. This is done by studying the reflectivity spectroscopy and permeability as a function of the photon energy that is important to the material, from which many important optical parameters can be found.

It is also known that polymer blends is a combination of two or more polymers that are prepared by mixing polymers in different states (liquid and solid state or molten state) for fabricate unique membranes the versatile with fascinating properties for a widely modern applications [7-9].

The present work, uses a diamond paste in a completely different way used which will hopefully provide new qualitative of polymer blend, where diamond paste blend with a second polymer the "epoxy resin", to obtain new blends with desirable optical properties that enable us to use them in electronic devices. The diamond paste has many uses where consider a very economical agent, due to its distinctive characteristics that make it an important component in many machines and radio systems. In addition to being used as cutting tools, honing metal blades and polishing surfaces [6, 10]. This is based on the extents of the diamond paste, ranging from the most roughness (20-90 microns) to the softest, (0.25-3microns). There are two main types of diamond paste: monocrystalline which is most common type, particles in this type of paste have a longer and more flat shape, so the cutting edges are lower and the other type multi-crystalline. In addition to diamonds as an attractive material, considered as on the other hand diamond films also highly attractive due to own have a set of unique properties such as; very hard, highly stable and very resistant. Because of these properties which beneficial in many applications, there are other potential uses after certain making necessary improvements that make them suitable for use in many photovoltaic devices applications. For example, they can be used as a protective layer for photovoltaic solar cells to reduce the corrosion of these cells due to environmental influences, especially the effects of sand and dust after making high transparency in order to minimize the impact on the solar cell efficiency [11,12].

2. MATERIALS AND METHODS

The thick polymer blends films were fabricate with varying amounts of diamond paste 0, 0.15 0.35, 0.55 and 0.75 by undergoes the following three stages:

- prepare bases: A glass mold was used and its base was encased by paper (over-Heat) with dimensions (20×20 mm).
- Preparation materials: The epoxy resin (EP10, Saudi origin "K. S. A.") was used as a matrix material. The ratio of resin to hardening material was (3:1) while the additive was diamond paste (particle size 0.25 micron) produced by Struers Com.
- Molding of polymeric materials. The diamond paste was blends with a weight of X = 0, 0.15 0.35, 0.55 and 0.75 with the matrix material (EP10 epoxy resins) for 10 minutes by hand molding and using a glass case. The hardening material was then added with continue blend for five minutes. The casting method was used to obtain the thick membranes of the polymer mixtures with a thickness of 5 microns.

The value and behavior of reflection in membranes generally depends on three main factors: thickness of the membrane, roughness of the surface and type of membrane material. The presence of topography, surface defects and high roughness of the membrane surface increases the dispersion value and increases reflectivity.

The reflectivity is also increased by increasing the thickness of the membrane by relying on the spectral permeability which decreases by increasing the thickness of the membrane and the coefficient of absorption which increases with increasing thickness according to the relationship [13]

$$T' = (1 - R')^2 exp(-\alpha t) \quad (1)$$

Where T' permeability, R' is reflectivity, α is absorption coefficient and t is thin film thickness.

The effect of thickness on the reflectivity spectrum is a characteristic of films only. It occurs within the relative wavelengths of the thickness of the films. This phenomenon occurs because of the overlap between the reflected wave from the upper surface of the film and the reflected wave from the lower surface, so 10 microns of thickness and visual measurements have been adopted.

The reflectivity of the absorbance and permeability spectra of these thick films was calculated according to the following relationship [13]:

$$R' = 1 - A' - T' \quad (2)$$

3. Results and Discussion

As it was indicated in (Fig. 1 and 2), the spectra of the change in reflectivity and absorbance for the thick films of polymeric blends, appear as a result of the change of photons energy. The photon energy plays a crucial role in the reflectance spectra, since we assign the peak in the reflectance spectra to within the range of energies adopted in measurement 1eV to 4eV. Spectral of reflectance for the thick polymer blends films at different energies of photons are presented in Fig. 1. Observe from Figure 1 increase the spectral reflectivity according to the increase of the photon energy until it reaches its peak at photon energy 4eV. Also, it's interesting observe that the reflectivity of these films takes low values at energies rang 1eV to 2eV due to low permeability and high absorbance at that range of photon energy, which is clearly shown in Fig. 2 that shows the absorbance spectra.

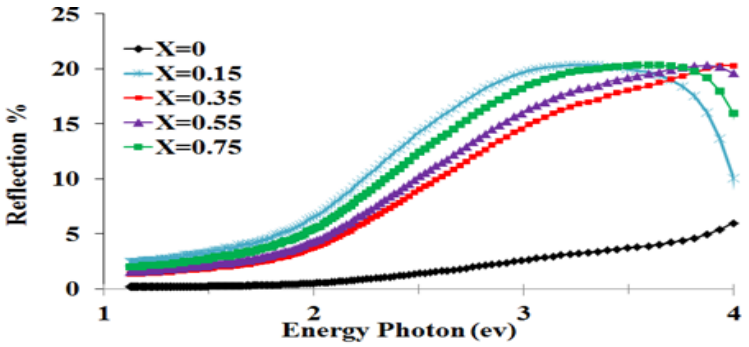

Fig. 1. shows the relationship between the reflectivity and energy of the falling photon.

The transmittance spectrum of thick polymer blends depends on the chemical and crystalline structure of the material. Also it depends on the thickness of the film and the topography of the surface through its dependence on spectrum reflectivity and absorbance (represented by a factor of absorption) according to the relationship (1). The transmittance is inversely proportional to the thickness of the film. Higher thickness provides a greater opportunity for different optical absorption phenomena in the film, thereby attenuating a larger part of the falling beam [14].

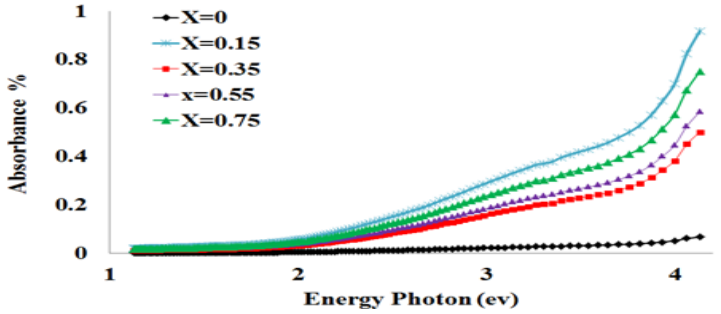

Fig. 2. shows the absorbance change with photon energy.

The Fig. 3 data exhibited that the increasing photon energy led to clear and significant reduced of films transmittance. The results indicate that diamond paste concentration affects the state of the transmittance, which has a dominating influence on the optical properties. The impact strength of photon energy increased for each increase in diamond paste content where the Fig. 3 data indicates that all polymer blends are stable up to 2 eV and then undergo reduce in the energies range (2 - 4 eV). This decrease can be interpreted as being due to the increase of reflectivity in the ranging of the photon energy (2-4eV), comparison to the reflectivity value of Fig. 1 with the coefficient of absorption in this region as shown in Fig. 4.

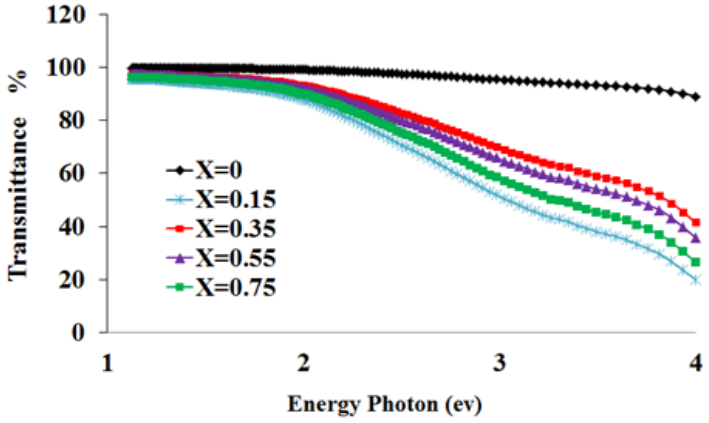

Fig. 3. shows the transmittance as a function of the photon energy.

The absorption coefficient is calculated in terms of the measurement of transmittance and reflectivity using the following relationship:[15,16]

$$\alpha = \frac{1}{t} ln\left(\frac{(1-R')^2}{T'}\right) \quad (3)$$

The absorption coefficient depends on the energy of the falling photons, the wavelength and the type of electronic transitions that occur between the energy packets. Where it is through the absorption coefficient setting an approximate conception of the structure of the power packs of films prepared. Fig. 4 shows the change in the optical absorption coefficient for thick films prepared polymer blends for X = 0, 0.15, 0.35 and 0.75. It is generally

observed that the thickness of the thick polymer blends prepared has low absorption coefficient (4×10^3 cm^{-1}) for the above ratios.

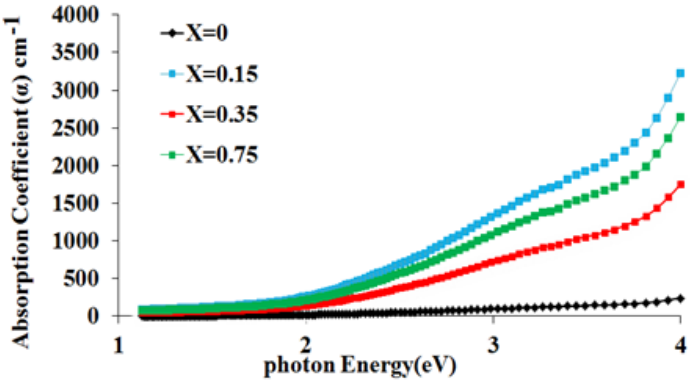

Fig. 4. shows the change of the absorption coefficient values for the added ratios of diamond paste.

Fig. 5 shows the ratio of X = 0.55, where it has a high absorption coefficient of $5x10^6$ cm^{-1}, and the absorption coefficient decreases at varying rates depending on the composition of the film and its components, where the absorption coefficient values are converged at high energy values. The values of the absorption coefficient indicate a high probability for direct electronic transitions, at low energies, i.e., in the visible region, the absorption and transmission of electrons from the valence band to the conduction band generates an electron-gap pair. These processes are called basic absorption processes.

Returning to Fig. 4, can be observed that thick films with ratios X = 0, 0.15, 0.35and 0.75 have the highest value for the absorption coefficient at 2eV to 4eV and then decrease until they reach a somewhat convergent value at energies below 2eV. The results of Fig. 5 show the film at X = 0.55, the highest value of the absorption coefficient at the low energy zone 1eV to 2eV, and the absorption coefficient reduced to 4eV, which has a high value of the absorption coefficient for direct electronic transitions, and can be utilized in the solar cell industry.

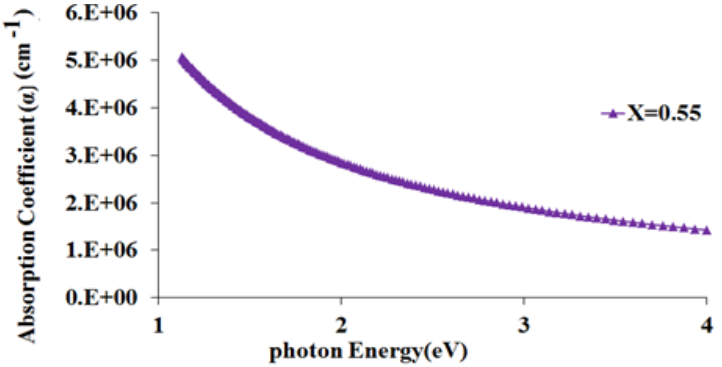

Fig. 5. Shows the change in the absorption coefficient of the ratio x = 0.55 with photon energy

While the extinction coefficient refers to the amount of attenuation of the electromagnetic wave as it passes through the physical medium, and on this basis, its value is determined by the interactions of the electromagnetic wave with the medium.

The extinction coefficient is calculated from the relationship[17]:

$$k = \frac{\alpha\lambda}{4\pi} \tag{4}$$

Fig. 6 shows the change in the extinction coefficient with the photons' falling energy to the thick polymer blends prepared

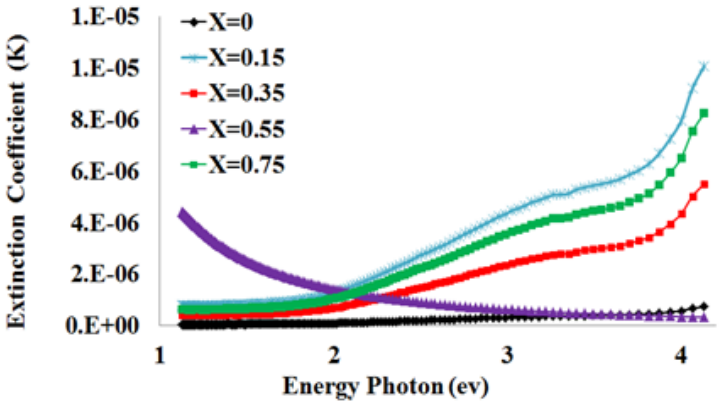

Fig. 6 . Extinction coefficient with photon energy

The refractive index is a function of spectral reflectivity (R') and the Extinction coefficient (K), where the results of spectral reflectivity and the coefficient of inertia were reflected on the refractive index results. The behavior of the refractive index changes according to the preparation conditions and the technique used in the preparation. Fig. 7 shows a change in the refractive index of thick polymer blends, where the refractive index values for the thickness of thick polymeric binders (2.4 - 3.4).

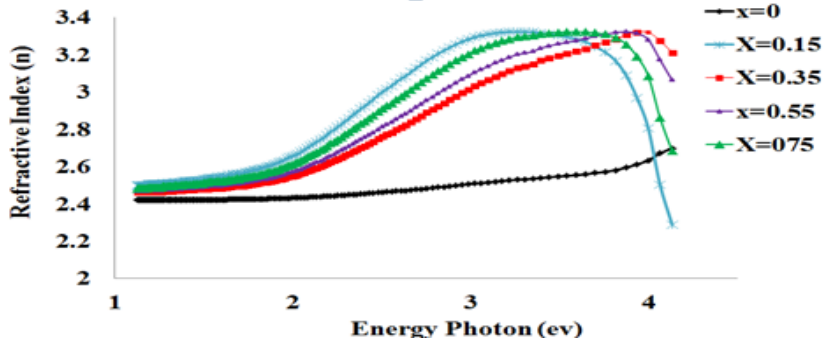

Fig. 7. shows refractive index with photon energy.

By knowing the refractive index n' and the extinction coefficient (K), the real ε_1 and imaginary part ε_2 of the dielectric constant can be calculated from the following two ratios[18]:

$$\varepsilon_1 = n^2 - K^2 \tag{5}$$

$$\varepsilon_2 = 2nK \tag{6}$$

The results of the measurement of the true and imaginary dielectric constant are reflected in a similar behavior to refractive index results with different numerical values. Figs. 8 and 9 show the change of the real insulation constant and the imaginary dielectric constant with the photon energy for thick polymer blends respectively

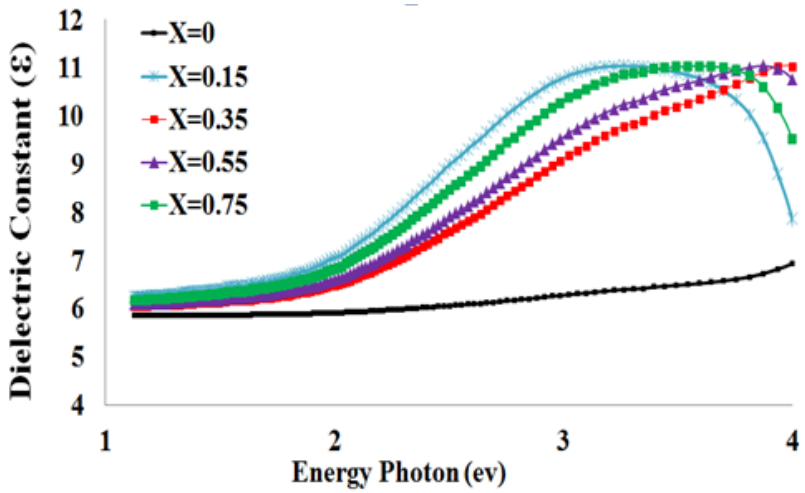

Fig. 8. shows the change of the real dielectric constant with photon energy

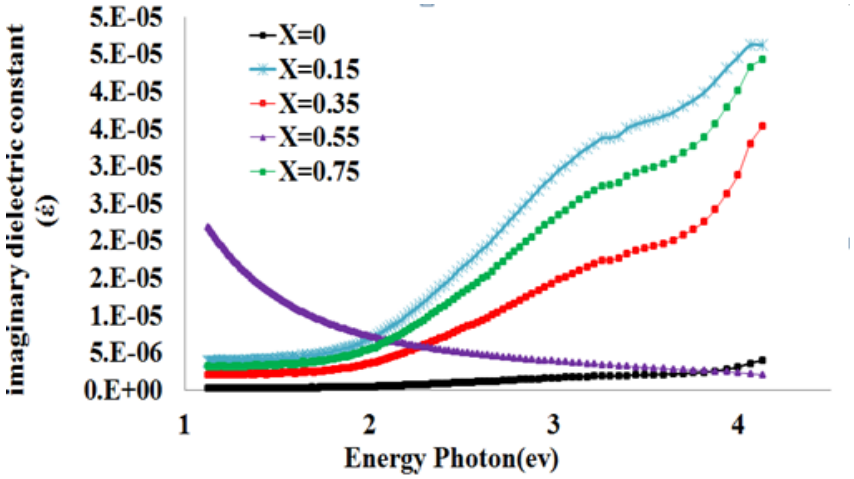

Fig. 9. shows the change of the imaginary dielectric constant with photon energy.

The permissible direct optical band gap value is calculated by plotting the relationship between the photon and the energy. Fig. 10 shows the graphic relationship plot between photon energy. In order to determine the value of the energy gap for the direct transmission allowed in Fig. 10, in the high absorption regions, linear value changes with the photon energy. This confirms that the direct electronic transitions allowed in the thick polymeric fluid membranes do not appear in the curves of other transitions, indicating that the direct electronic transport permitted in thick polymer blends films is possible.

It is possible to calculate the value of the permissible direct optical band gap of the thick polymer blends membrane in Fig. 10 by extending a straight line that is a finite extension of the photon's energy axis and the intersection point represents the value of the optical band gap for the direct transmission allowed for the thick polymeric membrane prepared.

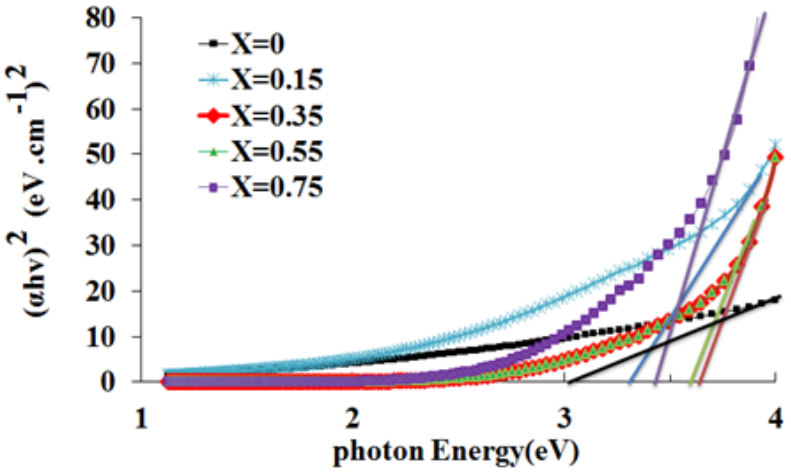

Fig. 10. shows the change of $(\alpha hv)^2$ with photon energy.

Table 1. shows the energy gab of the samples.

Sample	Eg(eV)
0	3.1
0.15	3.7
0.35	3.65
0.55	3.4
0.75	3.3

4. Conclusions

The results of the optical properties of new polymer blends presented based on the thick films of epoxy and diamond paste which have been prepared by casting method. The optical property data obtained for the absorption values of this polymer blend provide conclusions about the potential use of these materials as a protective layer in photovoltaic solar cells applications by adjusting the additive ratios in the mixture. In particular, the ratio of x = 0.55 only has high absorption values in the region 1eV to 4eV, making it suitable for such these uses. According to optical properties, all optical constants (refractive index, absorption coefficient, extinction coefficient, real and imaginary parts of the fixed insulating link) increases with the increase of the diamond paste content in the samples. Moreover, the results have been presented in this study also suggest that it is possible to regulate the additions of diamond paste ratio and optimize the optic performance by adjusting the composition ratio and structure of polymer blend to obtain films which possess good optical properties.

5. References

[1] K. F. Freed, "Phase Behavior of Polymer Blend", Springer-Verilog Berlin Heidelberg, 183 (2005): 1
[2] T. C. Mokhena, V. Jacobs, and A. S. Luyt. "A review on electrospun bio-based polymers for water treatment." eXPRESS Polymer Letters 9(10) (2015):839–880.

[3] M. Ellahi, Y. Gao, and H. Yang. "Effects of di and tetra functional epoxy monomers structure on the morphology and the electro-optical properties of polymer-dispersed liquid crystal films." International Journal of Science and Technology Research 2(3) (2013): 127-131.
[4] A. Rauf, R. J Hand and S. A. Hayes. "Modifying the Refractive Index of Epoxy Resins Using Reactive Diluents to Enable Optical Self-Sensing in E-Glass Fibre Composites." In Applied Mechanics and Materials Trans Tech Publications 625 (2014): 90-93.
[5] V. Prajzler, P. Nekvindová, P. Hypš, O. Lyutakov, and V. Jeřábek. "Flexible polymer planar optical waveguides." Radioengineering 23(33) (2014): 776-782.
[6] S. Meškinis, A. Čiegis, A. Vasiliauskas, K. Šlapikas, R. Gudaitis, I. Yaremchuk, V. Fitio, Y. Bobitski, and S. Tamulevičius. "Annealing effects on structure and optical properties of diamond-like carbon films containing silver." Nanoscale research letters 11(1)(2016): 146.
[7] C. Grosse, M. A. Ras, A. Varpula, K. Grigoras, D. May, B. Wunderle, P-O. Chapuis, S. Gomès, and M. Prunnila. "Microfabricated sensor platform with through-glass vias for bidirectional 3-omega thermal characterization of solid and liquid samples." Sensors and Actuators A: Physical 278 (2018): 33-42.
[8] S. A. Alekseev, A. S. Dmitriev, A. A. Dmitriev, P. G. Makarov, and I. A. ikhailova. "Functional energy nanocomposites surfaces based on mesoscopic microspheres, polymers and graphene flakes." Journal of Physics: Conference Series. IOP Publishing 891(1) (2017): 012361.
[9] S. Pashaei, M. M. Avval, Siddaramaiah, and A. A. Syed. "Investigation on thermal, mechanical and morphological properties of epoxy/UHWPE blends." J Eng Appl Sci 5(12) (2010): 26-37.
[10] K. R. Muratov, , E. A. Gashev, and D. M. Lagunov. "Influence of diamond paste on abrasive finishing." Russian Engineering Research 37 (8) (2017): 744-746.
[11] R. Simões, and V. F. Neto. "Nanodiamond coated glass as a protective layer in solar cells." Materials Today: Proceedings 2.1 (2015): 230-235.
[12] R. Simões, V. F. Neto, J. C. Mendes, and L. Pereira. "Diamond and other carbon related materials applications in photovoltaic solar cells." Electro/Information Technology (EIT), 2013 IEEE International Conference on. IEEE, 2013.
[13] B. K. H.Al-Maiyaly, S. H. Mahdi, K. A. Jasim , M. H. Mahdi, and N. T. Abdul.Hameed." Synthesis and Characterization of $Hg_{1-x}Cd_xBa_2Ca_2Cu_3O_{8+\delta}$ thin film Superconductors prepared by DC Sputtering" Journal of Chemical, Biological and Physical Sciences. 5(3)(2015): 2630-2941.
[14] S. A. ALY, ALAA. A. AKL. " Influence of film thickness on optical absorption and energy gap of thermally evaporated $CdS_{0.1}Se_{0.9}$ thin films" Chalcogenide Letters 12(10) (2015) 489 – 496.
[15] F. Demichelis, G. Kaniadakis, A. Tagliferro, E. Tresso, Journal of Applied Optics 26 (1987): 737
[16] L. Berggren, Optical absorption and Electrical conductivity in Lithium Intercalated Amorphous Tungsten Oxide Films, Act Universitatis Upsaliensis, Uppsala(2004).
[17] J.Taus,"Amorphous and Liquid Semiconductor", Plenums Press.NewYork and London. 18(1974).
[18] S.O.Kasap," Principles of Electronic Materials and Devices", 2nd edition, Mc Graw Hill (2002).