UNIVERSITY OF NIS
FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE

in cooperation with
UNIVERSITY OF NOVI SAD
FACULTY OF TECHNICAL SCIENCES
DEPARTMENT OF CIVIL ENGINEERING AND GEODESY

UNIVERZITET U NIŠU
GRAĐEVINSKO-ARHITEKTONSKI FAKULTET

u saradnji sa
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PhIDAC 2019 PhIDAC

V INTERNATIONAL SYMPOSIUM
FOR STUDENTS OF DOCTORAL STUDIES IN THE FIELDS OF CIVIL ENGINEERING, ARCHITECTURE AND ENVIRONMENTAL PROTECTION

V MEĐUNARODNI SIMPOZIJUM
STUDENATA DOKTORSKIH STUDIJA IZ OBLASTI GRAĐEVINARSTVA, ARHITEKTURE I ZAŠTITE ŽIVOTNE SREDINE

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EDITORAL NOTE:

The Faculty of Civil engineering and Architecture of University of Nis organizes the Fifth International Symposium of Doctoral Studies' Students in the fields of Civil Engineering, Architecture and Environmental Protection "PhIDAC 2019".

The first Symposium of the Doctoral Studies' Students "PhIDAC 2009", held in September 2009 in Nis, confirmed the expectations of Prof. Slavisa Trajkovic and Professor emeritus Radomir Folic, the founders of this symposium, that the two-day meetings of the students of Doctoral studies and their professors would be of invaluable use both for young researchers and their tutors. Namely, a great number of published and presented papers, as well as open discussion on the quality of paper, directions in further researches and relationships between doctoral students and tutors demonstrated that the Symposium fulfilled the expectations of the participants and that the organization of new meetings should be continued.

At the Second Symposium "PhIDAC 2010" held in Novi Sad, the symposium programme was expanded, i.e. the field of environmental protection was also introduced as the third thematic field with the expectation that this multidisciplinary area should be more closely introduced to young researches in the fields of civil engineering and architecture.

The organizers of the Third Symposium "PhIDAC 2011", also held in Novi Sad, decided that the symposium should be international and thus they opened new possibilities for affirmation and development of young researches from Serbia, as well as of their colleagues from the Balkans.

There were 66 papers dealing with topics in the fields of civil engineering, architecture and environment protection that were submitted for the fourth international symposium of students of doctoral studies "PhIDAC 2012". The papers covered a wide range of scientific topics. All the papers were reviewed. On the basis of the reviews, it was concluded that the young researchers provided a significant contribution to the development of scientific thinking.

Members of the international scientific committee actively participated in the preparation of the symposium and reviewing of the papers. For this symposium too, the proceedings including papers in English and Serbian were included, which provides better and more productive communication and exchange of experience with the colleagues from abroad.

We would like to thank all the authors and co-authors of the papers and their mentors, and it is our wish that the young researchers would continue their successful careers and persist in realization of the goals they have set.

Nis, October 2019 Editors

THE CONTENT:

SESSION CIVIL ENGINEERING AND ENVIRONMENTAL PROTECTION / OBLAST GRAĐEVINARSTVO I ZAŠTITA ŽIVOTNE SREDINE

PhIDAC 2019 PhIDAC
V INTERNATIONAL SYMPOSIUM FOR STUDENTS OF DOCTORAL STUDIES IN THE FIELDS OF CIVIL ENGINEERING, ARCHITECTURE AND ENVIRONMENTAL PROTECTION

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OLED LIGHT SOURCES IN ARCHITECTURE

Abstract: *A novel approach in architectural interior design requires application of novel technical achievements. One of such achievements is organic light emitting diode (OLED) light source, which can have wide application due to specific characteristics. Very good properties lead to application in various areas, like in automotive industry, in tablets, displays for digital camera, TVs, in mobile telephones... However, one of the most promising areas is lighting design. These innovative luminary products can enable the specific integration of lighting and architecture, in the way that was not possible in the earlier years. It is interesting that OLED light sources can be directly integrated into architectural materials. This possibility can also be used for applications in decorative lighting, as well as free-standing luminous objects. Therefore, all participants involved in these areas should become familiar with the basic characteristics of equipment, properties and possibilities of implementation, which is the goal of this paper.*

Key words: *OLED light sources, architectural design, lighting design, application, structure*

1. TENDENCIES IN OLED DEVELOPMENT

OLED (Organic Light Emitting Diode) components are new components that, due to their characteristics, can have a wider application. According to day-to-day innovations and quality solutions, OLED is expected to be widely used in many areas. Thus, they have significant applications for mobile phones, tablets, screens for digital cameras, televisions, in the automotive industry as well as in the field of lighting, and especially the decoration of a certain space. The innovations that have been discovered allow even windows to be installed instead of the classic ones, which can be an artificial light source when there is no daylight. With these OLED components and new equipment being refined, it would significantly reduce energy consumption, but above all artificial light would be made more similar to daylight and more pleasing to the eye. New technologies that are based on the use of OLED components offer great advantages when it comes to both manufacturing and design. For example, OLED-based TVs are significantly thinner than LED-based TVs, since fewer layers are required to produce them. Due to this advantage, TVs that are only 4 mm thin with exceptional design and very lightweight are produced [1].

The inspiration for the development of OLED components and technologies has been the firefly, that is, the way it creates and emits light. Specifically, tests of luminescent phenomena, responsible for the

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unique characteristics of the fireflies, have led to the development of a wide range of products. Luminescence is the appearance of the emission of "cold" light after the previous absorption of energy [2]. The use of electricity can cause the appearance of luminescence in certain organic materials, that is, electroluminescence occurs, which is then used to form a new type of component. In general, OLED structure consists of several tin organic films which are between two electrode layers and they are bright when the current passes through them. It is important that OLED light sources are environmentally friendly devices considering that do not contain harmful substances like mercury (which is involved in compact fluorescent light sources).

Although electroluminescence of organic materials was first observed at Nancy University in France in the middle of the last century, the first diode was reported in 1987 by Ching Tang and Steven [3]. According to the knowledge that light emission occurs at the center of the organic layer, OLED research has become more efficient. Significant progress has been achieved in polymer research in 1990 at Cambridge University when the high efficiency of green luminescent polymer devices was observed.

There is an idea on which was intensively and actively worked on, and that is the realization of a "smear" OLED that could coat a surface or spray on the surface a layer of that mixture [4]. Such a display would be very thin, about 100 nm, and would use solar energy. This idea that the OLED display functions as a solar panel can be realized thanks to the great similarity in the operation of solar cells and OLED components [3].

Significant progress in the production and increasing efficiency of OLED components is constantly accelerating. For commercial light sources, efficiency has been increased three times over the past three years, as well as brightness. In addition, the working life has increased three times, while the price has decreased three times. Source efficiency is greater than 60 lm / W and color reproduction rate (CRI) is higher than 90 [5].

In addition, OLED sources have an excellent degree of color reduction and contain in their spectrum less "harmful blue light" than other light sources (Fig. 1) [6]. By "harmful blue light" is meant the light of smaller wavelengths and thus of higher energy ($E = h\nu = hc/\lambda$). Sunlight, artificial light sources, illumination from the screen of computers, TVs, smartphones also contain this light... It can lead to degradation and damage to the eye if it is exposed to this light for a long time, but also to sleep disturbance. Therefore, OLEDs containing a small amount of light of smaller wavelengths are suitable for use, as shown in Fig. 2 [7]. The figure shows the spectra of light sources of color temperatures of 3000, 3500 and 4000 K. The measurements were made at ambient temperature of 25 ^{o}C.

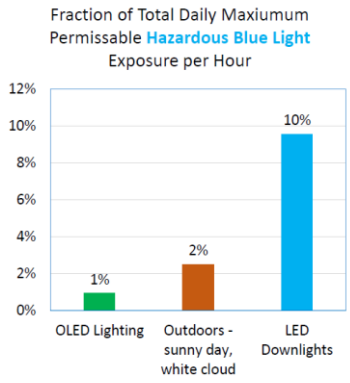


Figure. 1. Proportion of "harmful blue light" in light sources [6].

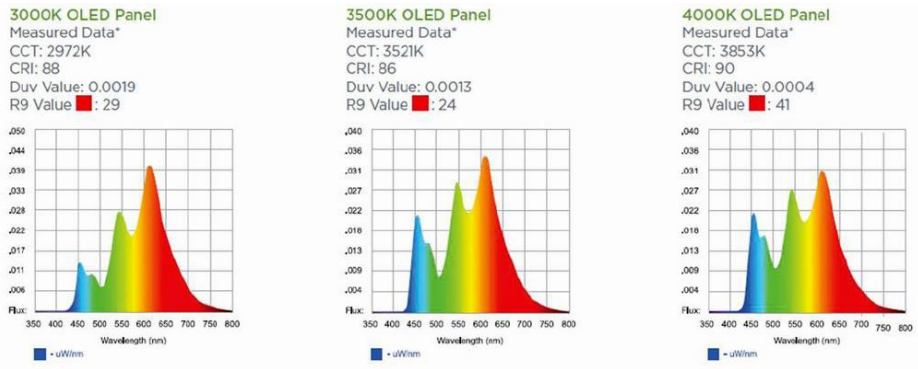


Figure. 2. OLED light source spectrum [7].

Firstly, it should be noted that white OLED has high energy efficiency and low power consumption. Its more extensive use for lighting would significantly reduce costs in the future. White OLED can be applied in large panels. The light it emits is significantly uniform, unlike LED sources that represent point sources, so it is more pleasant for the eye, similar to the natural light and annoying glare is avoided. The above differences can be observed by comparing lamps incorporating LED and OLED light sources, as it is shown in Fig. 3. In Fig. 3 (a) it is shown a lamp made of flexible silicone surface containing seven embedded arrays with LEDs (6x9). The whole body of this lamp can be bent to obtain the best position and the light to be directed in the best way. Also, white OLED can be incorporated into the flexible silicone surface, as shown in Fig. 3 (b). Such a silicone base can be practically adapted to any requirement and surface (positioned or wrapped around a piece of furniture) as can be seen in Fig. 3 (c) while providing comfortable light for reading. In this case, the incorporated illuminating surface can also bend in the direction most suitable for reading or working.

(a) (b) (c)

Figure 3. Lamps in which are incorporated (a) LEDs as well as (b), (c) OLED light sources [8].

2. APPLICATION OF OLED LIGHT SOURCES

It should be emphasized that in the area of architectural design (especially interior) it is very important to choose the type of illumination and light sources that will be best suited for the nature of visual tasks, for the material being processed and for the colors that were used in the interior space. This can be achieved by accomplishing architect participation as well as other engineers involved in interior and lighting design.

2.1. OLED lamps

Osram introduced the world's first lamp based on OLED technology at the “Light + Building Fair” in Frankfurt, in 2008. This Flat Lamp (Fig. 4) is one of the first products for which OLED technology has been used in the design of consumer products.

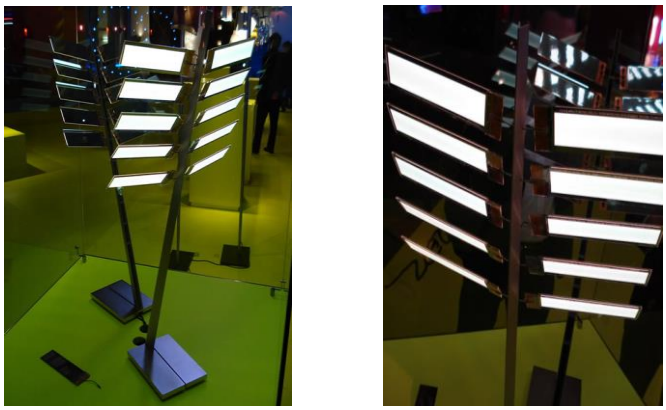


Figure. 4. The first lamp for which OLED technology was used in the design of consumer products [9].

The practical application of OLED is the OLED lamp for desktops. Firstly, it has a thin layer of material that provides light. There are OLED light sources in which colors can be adjusted. They are receiving a lot of attention and investing in their increasingly interesting design.

It should be emphasized that OLED lamps give light similar to natural lamps and that they do not contain any harmful or toxic materials such as mercury contained in compact fluorescent lamps (CFLs).

Our engineers who are working in foreign companies are involved in the production and design of these products [10]. One of recently designed lamps is shown in Fig. 5, which is 5 cm wide and only 0.5 cm thick. It produces a light color that is pleasant to the eye during the day and night. This lamp can be used during working, reading or simply for decoration of space. What is characteristic of this new generation lamp is that it can be used for floor, wall or ceiling. It consists of several panels and each of them can be independently moved around its vertical axis left or right by 90°, and in two places it is possible to move left or right by 90°. Since there is the ability to illuminate both from above and from the side, there are almost no shadows. In this way, adaptability to different requirements is achieved.

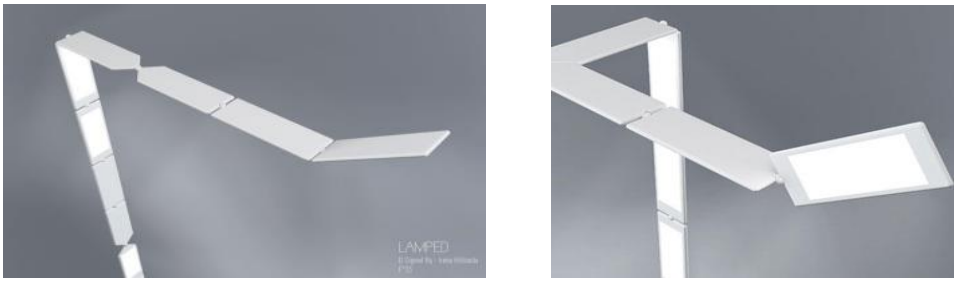


Figure. 5. Design of modular OLED lamps [10].

The lamp, which was inspired by the appearance of a cobra snake, was presented in 2014 at the Frankfurt fair and is shown in Figs. 6. The base is aluminum and a very thin mold has been successfully formed as no coolers were required to be installed.

Figure. 6. OLED lamp design inspired by cobra shaped [11].

2.2. OLED light modules

Due to all the features that OLED has, it is very interesting to use it for interior decoration and lighting. OLED-based illumination is different from other illuminations because it is possible to use (applying or incorporating) different impurities (molecules) to produce light of different colors. This gives the space a different, more attractive appearance (Fig. 7). Since light comes from the entire large surface, this light is more suitable for application than light obtained by other light sources [12]. In Fig. 8 is a modular installation display with OLED sources [11].

Figure 7. Application OLEDs for light modules [12].

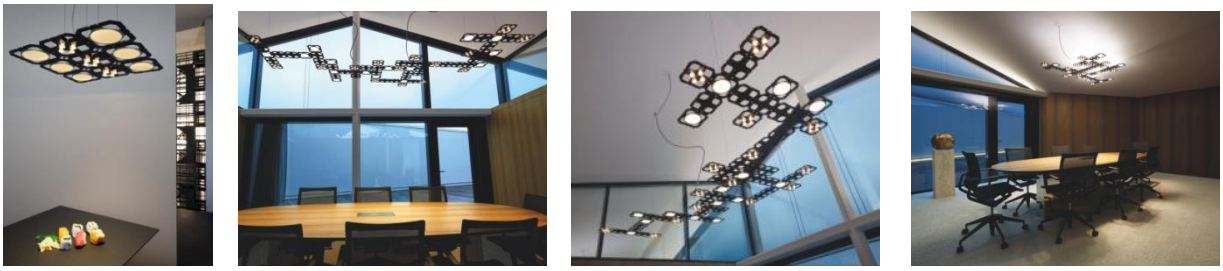


Figure 8. Modular panels with OLED sources [11].

It should also be noted that wallpapers containing OLED components that incorporate OLED light sources may soon be expected. It is a very attractive application for interior decoration. This can be a very interesting way to decorate the interior as it is shown in the Fig. 9 [13].

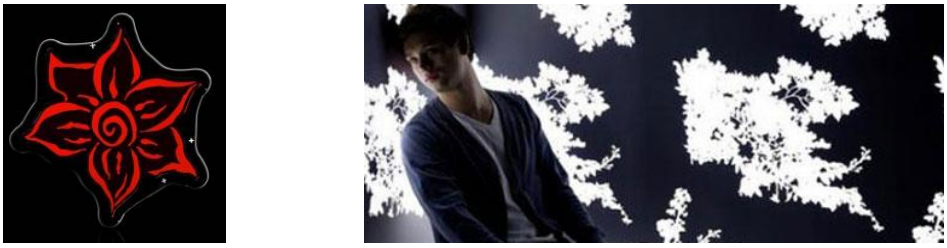


Figure 9. Application of OLED for decoration [14].

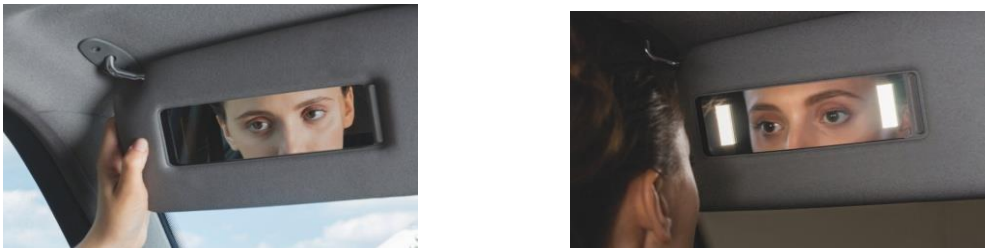
2.3. Transparent OLED light sources

A transparent OLED light source can completely cover the surface of the mirror. When it is turned off, it is transparent and when it is switched on it becomes a source of pleasant white light. This can be used in stores, thus increasing the attractiveness of the products which are offered (Fig. 10).

Figure 10. OLED light source on the entire mirror surface [15].

Also, the OLED light source can be practically integrated into the mirror, as it is presented in Fig. 11. When it is turned off, it is completely transparent and practically represents a part of the surface of the mirror. When a larger light source is turned on, the lights are emphasizing details, whether it is used in the bathroom or in the car.

(a)



(b)

Figure. 11. OLED light source integrated into the mirror (a) in the bathroom and (b) in the car [15].

3. SUMMARY

It is obvious that OLED light sources can be part of exterior and interior architecture. Their applications have many important advantages. Light which comes from OLED sources is better for health and especially for eyes because it is similar to the daylight. Also, organic alloy, which is a part of OLED structure, is flexible and it can adjust to any shape of surface. This is very important characteristic which leads to the development of increasingly more specialized lighting equipment and tools. OLEDs offer many advantages over other sources – they are thin, flat, transparent and tunable. All of this makes this type of luminaries acceptable for architectural lighting which could be functional or decorative and OLEDs could be used as signaling, interior, advertising, emergency lighting, but also as decorative, accent lighting. Besides that, materials which are used are not toxic and they are environmentally friendly. Also, one of main benefits is that OLEDs are very efficient and they do not need a lot of electricity to operate, so that could reduce energy cost for lighting. These characteristics could be essential for protecting and reducing the pollution.

The focus of paper is on new and modern integrations of these light sources in modern architecture. It is obvious that OLEDs application range depends on technological development of production techniques. Certainly, as these techniques progress, implementation of OLED will significantly increase and contribute to the sustainable development. The constant improvement of the characteristics of light sources enables the realization of inovative solutions. Therefore, if the advantages of OLED components are known, as well as the possibility of various applications, is very important for the further realization of the creative solutions of engineers and designers.

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