

MECHANICAL ENGRAVING LIGHTING SYSTEM USING LIGHT DISPERSION THROUGH WOOD FIBER

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Abstract:

The paper presents a new perspective on the superior valorization of wood, with a functional and aesthetic role through a lighting system for mechanical engravings by scattering light through wood fiber. Thus, the study targets aspects related to the wood grain pattern, the relationship between wood thickness and different optical effects of light used for the lighting system, combined with advanced manufacturing technology. As a case study, the concept of creating a lighting fixture with artistic value, made of birch wood, is presented. The mechanical processing was done at CNC, and the attached lighting system is an innovative one. The challenges consisted in establishing the optimal thickness of the solid wood semi-finished product, the dimensional stabilization of the wood, the mode of light dispersion and temperature reduction at the wood-luminophore interface. The novelty of the paper lies in the integration of design and simulation technology of all technological stages with that of processing. Last but not least, it should be mentioned that the resulting painting is interactive, being connected via a QR code to the site <https://proilavia.wordpress.com/2022/12/18/braila-2022/> where information about the history of the city of Braila can be accessed.

Key words: wood, wood grain pattern, mechanical engraving, lighting system, decorative function.

INTRODUCTION

The variety of wood grain patterns and wood colors have fascinated designers, engineers, mathematicians, architects, chemists, and researchers alike. The pattern of wood is influenced by both the macroscopic and microscopic structure of the wood and by the way the log is cut with respect to the main directions of the wood. The combination of the two aspects (pattern and color) provides the uniqueness of each wood species and even each piece of wood obtained. According to Harris (1973), Lachaud & Bonnemain (1984) and Kramer (2006), the formation of wood grain patterns depends on both chemical processes (biosynthesis and metabolism of auxin), genetic (as oscillations of cambial orientation in some species, possibly mediated by the term chemotrope) and dynamic processes related to the transport of auxin through the vascular cambium and the initial fusiform reorientation, which lead to the formation of wavy patterns of grains. The exploitation of wood grain patterns in art and design has been carried out since ancient times, but current technology allows the reinterpretation and use of the structural models of macroscopic and microscopic wood cells through various design methods, some of which are based on fractal art (Song & Zhao 2012). An important step in capitalizing on the wood grain pattern is the combination with different lighting systems. The light is filtered through the wood veneer, producing optical effects. Moreover, the warm color of the illuminated wood provides an ambient light with positive psychological effects compared to the negative effects on human health produced by artificial light, as presented in the results of research (Ghosh et al. 2022). Excessive and direct use of artificial light either outdoors or indoors has a negative impact similar to light pollution that has the effect of suppressing melatonin and disrupting the circadian rhythm, contributing to the occurrence of sleep disorders, mood and mental health disorders, obesity, cancer, cardiovascular diseases and fertility and reproductive difficulties, aspects highlighted in the research report (de Miguel et al. 2021, Foster (2021), Gravito et al. 2023). Artificial light sources vary depending on the way in which the light is produced. Thus, the best known sources are: incandescent bulbs that produce light by heating a tungsten filament until it glows

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(Fig. 1a); halogen lamps - a type of incandescent bulb that uses a halogen gas to improve efficiency and lifespan (Fig. 1b); fluorescent lamps - use an electric current to excite mercury vapor, which then emits ultraviolet light that causes a phosphor layer inside the tube to glow (Fig. 1c); LED (light-emitting diode) lamps - use semiconductors to emit light when an electric current passes through them (Fig. 1d); high-intensity discharge (HID) lamps - produce light by an electric arc through a gas and include types such as metal halide, mercury vapor, and high-pressure sodium lamps (Fig. 1e); gas-discharge lamps - a broad category that includes neon, xenon, and other lamps that create light by passing a current through a gas (Fig. 1f); and combustion sources - produce light by burning, such as candles, oil lamps, and gas lamps.

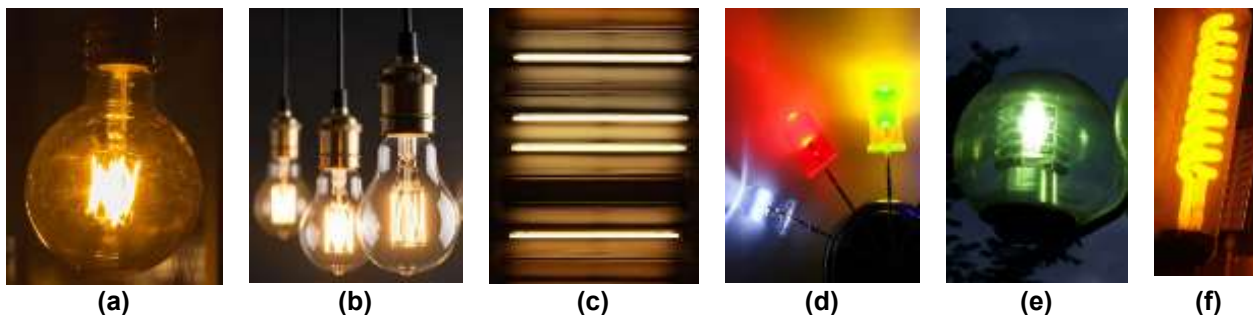


Fig. 1.
Types of artificial light sources.

Thus, from medical research to improve the quality of life and physical and mental health, it results that engineers and designers/architects should design lighting systems that maximize the amount of sunlight and require minimal exposure to artificial light. The introduction of an artificial light filter such as wood can be a solution to reduce the negative effects of artificial light. From the specialized literature, it results that there is no lighting system with light dispersion through wood fiber that is based on mechanical engraving, but only a few references related to the treatment of wood to chemically obtain its semi-transparency. The inventor C. Arthur Gerfers III presents a lighting system that uses the transparency of wood in the patent (Gerfers 2005). Since 2018, the company Volatiles has been using the LED lighting method, with tactile sensors and programmable for glass mosaic panels, luminous concrete, natural stone and wood, considered by them to be a modular, autonomous, programmable lighting system and available in different shapes. The company Schorn & Groh makes veneer lighting fixtures in which the light source is located behind the veneer, its structure having a translucent appearance. The company Slate-Lite, Germany presents the materials and a method for lighting backlit stone veneers.

OBJECTIVE

The objective of the paper is to present a demonstration model of obtaining a mechanical engraving lighting system using light dispersion through wood fiber, starting from the functional aspect, the method of obtaining it to the aesthetic aspect and connecting the model to digital technology.

MATERIAL, METHOD, EQUIPMENT

Materials

In this study, birch wood (*Betula pendula* (European White Birch)) was chosen knowing the physical and anatomic features of this wood species: it has a yellowish white color, quite uniform, sometimes showing curly fiber similar to cherry; there is no distinct difference between sapwood and heartwood, it is in most cases non-existent; the fiber is straight, fine, uniform, rarely showing slight undulations; the pores are of medium size, quite numerous and evenly spread throughout the annual ring; there is no difference between latewood and earlywood within the annual ring, and the rings are hardly visible, the difference between them being very small (Filipovici 1965, Radu 2017). The use of color and wood grain patterns contributes to reducing the negative effects of artificial light on human health. due to the chemical composition of the cell walls of wood as well as their structural organization, light is reflected and radiated differently, resulting in a set of shades, characterized by a basic color and important shades. When exposed to light, different components of wood, such as cellulose and lignin, absorb and emit light at different wavelengths, with significant absorption peaks in the ultraviolet and visible spectrum. For example, lignin shows high absorption in the UV spectrum, while cellulose emissions can be observed in the visible spectrum. The 0.6 mm thick veneer blank was cut to dimensions of 380 mm x 280 mm (bxh (b – width, h - height)). Another important material of this system is the PMMA acrylic sheet EndLighten® (polymethylmethacrylate $CH_2=C[CH_3]CO_2H$), with optical properties presented in Table 1. The wood sheet was fixed to the PMMA plate using a transparent double-sided adhesive film (h=0.1mm), having the optimal properties for bonding optical substrates.

Table 1

Optical and Electrical Properties of PMMA EndLighten®

Property	Parameters
Refractive index	1.48
Dielectric constant (1MHz)	2.6
Dielectric strength (kV mm ⁻¹)	15
Dissipation factor (1MHz)	0.014
Surface resistivity (Ohm/sq)	1014
Volume resistivity (Ohmcm)	2-14 x 10 ¹⁵

In addition to the basic materials, other functional materials were also used, as can be seen in Fig. 2 (Tilea et al. 2025).

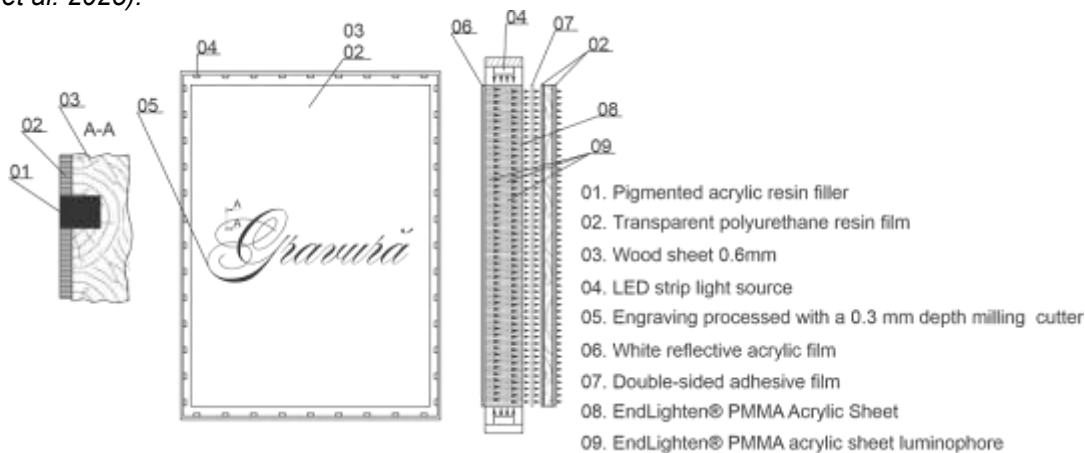


Fig. 2.
The main parts of the light system.

Method & Equipment

Obtaining the lighting system consisted of several stages, the most important of which are highlighted in the diagram in Fig. 3.

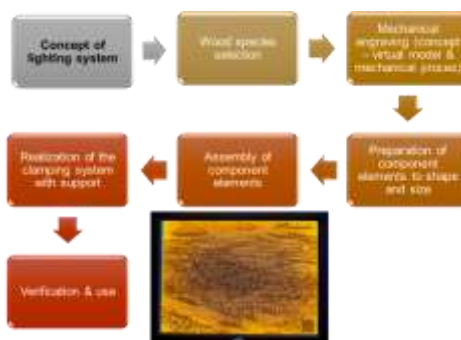


Fig. 3.
The main parts of the light system.

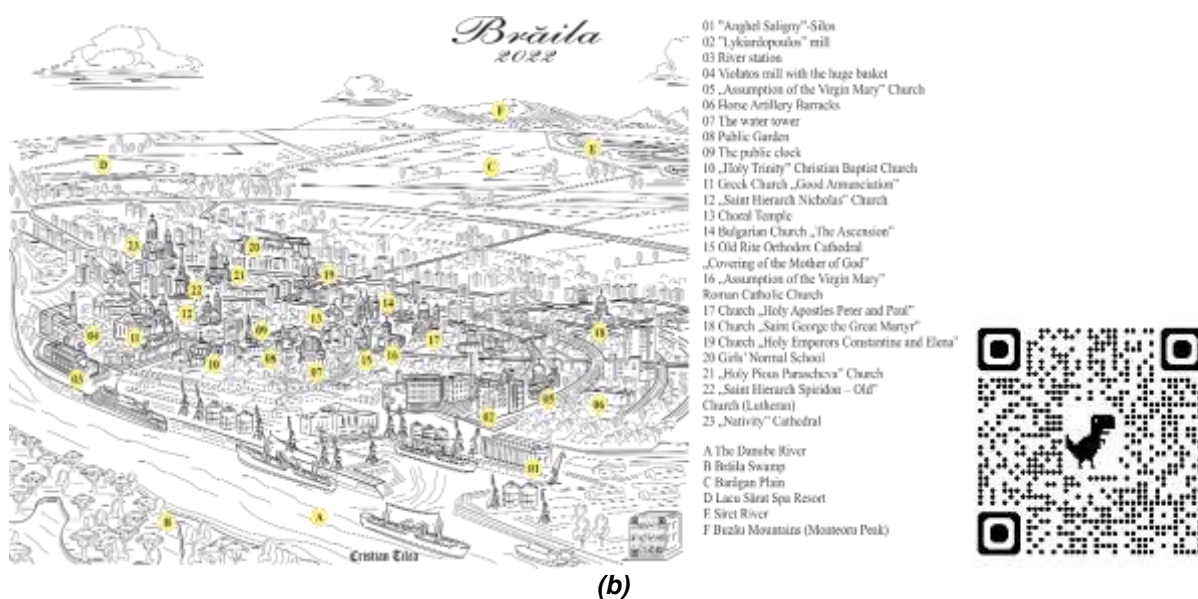
Mechanical engraving (concept – virtual model & mechanical proces)

In the present work, the concept of the engraving started from the request of the local authorities, to carry out a study followed by research and design of a representative graphic work for the city of Brăila. Thus, photographs were taken both from the plane and with the drone at an altitude of 800 m, taken from the right bank of the Danube (Smârdan) to capture as many buildings in the city of Brăila as possible. Based on a rigorous analysis of the photographs, a photograph was chosen as the basis for graphic processing in Corel Draw, making vector graphics with the graphics tablet during approx. 3 months (Fig. 4). The most important

historical buildings were highlighted, and information about these buildings was added to the website <https://proilavia.wordpress.com/>, which can be accessed with the QR code.



(a)



(b)

Fig. 4.

The city of Brăila: a) photograph made by Tilea C; b) vector graphics and QR code.

Processing and assembly of the component elements

After the support for the engraving was prepared, consisting of a sandwich plate formed by the PMMA plate, the adhesive foil film and the birch wood plate fixed with polyurethane resin, the graphic model of the engraving was implemented as a milling program on the CNC machine. The milling was done with a cylindrical milling cutter with grooves "Datron" with a diameter of 0.3 mm, with a depth of 0.6 mm - the thickness of the wood sheet (Fig. 5).



Fig. 5.
The Capture during the CNC milling operation.

The illumination of the wood engraving was done using an LED strip applied to the edge of the PMMA plate, the diffusion of light through the wood fiber being based on the light beams reflected at 90 degrees to the light source. The LED lighting source is dimmable with a power consumption of less than 40W. Their lifespan is guaranteed by the manufacturer to be over 40,000 hours of operation and their replacement is done in the assembly workshop. The lighting system is powered at 220 V AC, 50 Hz., using a power plug. The electrical and electronic system of the lighting fixture is operated using an electronic touch switch (touch system), maintaining its touch represents the increase in light intensity until reaching maximum and its resumption in a continuous loop until the touch (actuation) is released. This lighting approach is not limited to the rectangular geometry presented but can also be used for other shapes, such as circular or polyhedral. On the edge of the engraved panel, both for optimal fixation of the lighting elements and as a thermal radiator, an aluminum T-profile was applied. The decorative aspect was ensured by means of the frame, and on the lower part with a wooden plate, as can be seen in Fig. 6.



Fig. 6.
Mechanical Engraving Lighting System.

CONCLUSIONS

The paper presents the principle of creating a lighting system with light dispersion through wood fiber, using phosphors in double-sided adhesive foil and PMMA plate applied to wood, with a functional, aesthetic and cultural role.

The novelty of the lighting system consists in:

- providing an indirect lighting system, by dispersing light through wood fiber, using phosphors;
- creating a composite system, consisting of several layers of materials with optical, thermal and elastic properties;
- integrating an electrical system that ensures the start/stop of the electrical power supply, as well as a dimmer/brightness regulator;
- integrating a thermal system to dissipate the heat produced by the light sources to the outside of the assembly
- creating an object with aesthetic values by customizing the model milled/engraved on wood;

- using a positioning system for the assembly, based on a magnetic grip, thus being able to be applied to any surface.

Through this invention, the authors have contributed to enriching the types of lighting systems, using current technologies, with reduced electricity consumption during operation, the product being a niche system for visual art, woodworking engineering, mechanical and electrical engineering, advertising, interior design and last but not least for human health.

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REFERENCES

- de Miguel AS, Bennie J, Rosenfeld E, Dzurjak S, Gaston KJ (2021) First estimation of global trends in nocturnal power emissions reveals acceleration of light pollution. *Remote Sens* (Basel); Vol. 13, 3311. <https://doi.org/10.3390/RS13163311/S1>.
- Filipovici J (1965) *Studiul Lemnului vol I* (in Romanian language), Ed. Didactică și Pedagogică, București.
- Foster RG (2021) Melatonin. *Curr Biol* Vol. 31(22):R1456-8. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0960982221014184>.
- Garavito GA Bennin F Barnett Ph Vindrola-Padros C (2023) What are the effects of artificial light on human health? An evidence brief. In *Rapid Research Evaluation and Appraisal Lab (RREAL)*, <https://www.rapidresearchandevaluation.com/>
- Gerfers III CA (2005) Translucent wood veneer lighting system – patent no. US20050018433A1 [Online]. <https://patents.google.com/patent/US20050018433A1/en?q=US+2005%2f0018433+A1> Accessed on 15.10.2025.
- Ghosh A, Kundu PK, Sarkar G (2022) Impact of light on human health - a brief review. *Sci. and Cult.* Vol. 88(5-6):162-169.
- Harris JM (1973) Spiral grain and xylem polarity in radiata pine: microscopy of cambial reorientation. *N Z J For Sci*, Vol. 3, pp. 363-378.
- Kramer EM (2006) Wood Grain Pattern Formation: A Brief Review, *J Plant Growth Regul*, vol. 25, pp. 290–301. DOI: 10.1007/s00344-006-0065-y.
- Lachaud S, Bonnemain JL (1984) Seasonal variations in the polar-transport pathways and retention sites of [3H] indole-3-acetic acid in young branches of *Fagus sylvatica* L. *Planta*, Vol. 161, pp. 207-215.
- Radu M (2017) Mesteacănul, lemnul designerilor, *Revista din lemn*, 21.12. 2017, online, https://revistadinlemn.ro/2017/12/21/mesteacănul-lemnul-designerilor/?utm_source=ZohoCampaigns&utm_campaign=Newsletter%2012%20ianuarie%202017_2018-01-11&utm_medium=email.
- Song SS, Zhao G (2012) Pattern design and fractal artistic expression based on wood macroscopic and microscopic structure, *Wood Research* vol. 57(4):523-530.
- Tilea L, Tilea C, Stanciu MD (2025) Sistem de iluminat al gravurilor mecanice cu dispersia luminii prin fibra lemnoasă. Propunere de brevet A/00509/4.11.2025, OSIM.