

35. ORGANIC LIGHT-EMITTING DIODE TECHNOLOGY: CURRENT TRENDS AND FUTURE GROWTH

Gerasimchuk S.N., Afanasiev A.A.

*Belarusian State University of Informatics and Radioelectronics
Minsk, Republic of Belarus*

Murzich L.F. – Lecturer

The paper deals with recent advancements, device structures, methodologies for light extraction, and breakthroughs in flexible Organic Light-Emitting Diodes (OLEDs). The potential applications of OLEDs in solid-state lighting and displays are discussed. Future research directions aimed at expediting OLED commercialization are displayed. Recent examples of highly efficient near-infrared (NIR) organic light-emitting diode (OLED) emitters are specially reviewed.

Organic light-emitting diodes (OLEDs) have rapidly become a prominent technology for full-color display panels and environmentally friendly lighting sources due to their exceptional characteristics. These features encompass superior color quality, wide viewing angles, mercury-free production, and notable flexibility, positioning OLEDs as a promising area for research and development. The recent interest in near-infrared (NIR) luminescence among scientists from diverse research domains is notable.[1]

The incorporation of NIR into organic light-emitting diodes (OLEDs) presents the advantage of developing compact, thin, and flexible devices. This integration reduces invasiveness, weight, and facilitates their integration into small consumer electronics. This technological advancement broadens the scope of OLED applications in various fields, from display panels to lighting sources, enhancing their versatility and functionality.[1]

NIR-emitting luminophores find numerous essential applications with a growing array of new uses. These applications include non-invasive imaging, security applications, photodynamic therapy, sensing, and solar cells. The luminophores utilized in these applications encompass fluorescent materials, metalorganic phosphorescent materials, inorganic nanoparticles. Notably, red-emitting fluorophores interact with biological materials like skin and blood, a critical aspect for potential medical applications.[1]

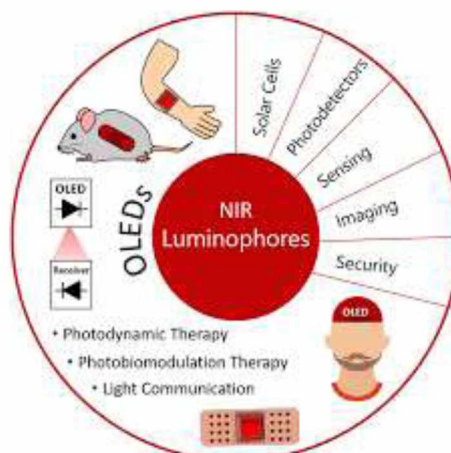


Figure 1 — Summary of the various uses of NIR luminophores with the focus towards OLEDs

Light emission in Organic Light-Emitting Diodes (OLEDs) is achieved through electroluminescence from organic materials under an electric field, utilizing mechanisms like fluorescence and phosphorescence. Understanding these mechanisms is crucial for optimizing OLED performance. Device architectures for OLEDs vary from single-layer structures to multilayer designs and tandem configurations, tailored to achieve specific light emission characteristics efficiently.[3]

Tandem OLEDs represent a more advanced architecture where multiple OLED units are stacked on top of each other, connected by charge generation and transport layers. This configuration enables efficient utilization of photons, as the emission from one unit can be absorbed by the subsequent units, leading to higher overall device efficiency. Tandem OLEDs can also incorporate different emitter materials in each unit, allowing for the generation of white light or improved color gamut.[5]

In the realm of smart lighting, OLEDs offer unprecedented design flexibility and energy efficiency, creating dynamic lighting environments tailored to user preferences and needs. With their ability to produce vibrant colors and uniform illumination, OLEDs are well-suited for architectural lighting, decorative fixtures, and ambient lighting in residential, commercial, and outdoor settings.[4]

In displays OLEDs are driving advancements in visual quality and user experience with applications ranging from smartphones and tablets to large-format TVs and virtual reality headsets. The self-emissive nature of OLED pixels enables true blacks, high contrast ratios, and wide viewing angles, resulting in immersive and lifelike imagery. Display technologies evolve and OLEDs are expected to play a central role in shaping the future of entertainment, communication, and information display.

In virtual reality (VR) and augmented reality (AR) headsets OLED displays provide immersive and lifelike visuals that transport users to virtual worlds and enhance real-world interactions. The fast response times and low latency of OLED panels minimize motion blur and input lag, ensuring smooth and responsive gameplay experiences in VR environments. VR and AR technologies become more mainstream what contributes OLEDs will continue to drive innovation in headset design and user interface development, unlocking new possibilities for entertainment, education, and training applications.[5]

Automotive applications represent another promising frontier for OLED technology, where thin and flexible nature of OLED panels enables innovative lighting solutions for interior and exterior lighting. OLEDs provide automotive designers with innovative opportunities to enhance safety, aesthetics, and brand identity through customizable dashboard displays and futuristic lighting signatures for headlights and taillights. Furthermore, OLEDs offer unique advantages in healthcare settings beyond their applications in wearable health monitors, medical imaging displays, and ambient lighting. Their flexibility and thin form factor make them ideal for integration into medical devices and equipment, enabling the development of lightweight and portable solutions for patient monitoring, diagnostic tools, and therapeutic interventions. Additionally, OLEDs can be utilized in surgical lighting systems to provide surgeons with accurate and glare-free illumination during procedures, enhancing precision and reducing eye strain. The OLED lighting's color temperature and intensity can be adjusted according to the unique needs of various surgical specialties, leading to better surgical results and enhanced patient safety.[6]

Moreover, OLEDs hold promise for phototherapy applications, where specific wavelengths of light are used to treat various medical conditions such as jaundice in newborns, psoriasis, and mood disorders. The precise control over light emission offered by OLEDs enables targeted therapy delivery while minimizing side effects, offering a non-invasive and potentially more effective treatment option for patients. [7]

In research laboratories and clinical settings, OLED-based microarrays and biosensors can be used for high-throughput screening of biomolecules, drug discovery, and disease diagnostics. The high spatial resolution and sensitivity of OLED-based sensing platforms enable rapid and accurate analysis of biological samples, paving the way for advancements in personalized medicine and early disease diagnosis.

The flexibility of OLEDs enables manufacturers to produce OLEDs using roll-to-roll manufacturing processes, comprising the production of flexible display and lighting products. This technology has the potential to lead to very flexible OLED panels for both display and lighting products, ensuring that any surface area – flat or curved – will be able to host a light source. OLEDs offer unique spectral power densities, allowing for the full coverage of the visible spectrum, and have the potential to revolutionize the lighting industry with their planar light emitters that are lightweight and have thin profiles. This lets lamp manufacturers and designers create unprecedented designs and provide dramatic effects, leading to the creation of new living environments in houses, offices, stores, and vehicles such as cars and airplanes.

The OLED market is expected to expand significantly in the upcoming years, driven by improvements in manufacturing methods and a rising need for high-quality displays. Key applications include consumer electronics, automotive displays, and lighting solutions. However, there are still challenges with production costs and longevity that are being addressed in research and development.

Overall, the future of OLEDs is marked by continual innovation and integration into diverse industries, driven by the pursuit of enhanced performance, functionality, and user experience. With ongoing advancements in manufacturing processes, and application development, OLED technology is poised to deliver transformative solutions that enrich our lives and surroundings beyond our current comprehension.[2]

References:

1. Recent advances in highly-efficient near infrared OLED emitters [Electronic resource]. – Mode of access: <https://pubs.rsc.org/en/content/articlelanding/2024/qm/d3qm01067h>. – Date of access: 17.03.2024.
2. The OLED Market Size, Growth Drivers, Opportunities Ahead, 2022-2030 [Electronic resource]. – Mode of access: <https://www.marketsandmarkets.com/Market-Reports/oled-market-200.html>. – Date of access: 17.03.2023.
3. A Review Paper on Organic Light Emitting Diode (OLED) [Electronic resource]. – Mode of access: <https://www.ijert.org/research/a-review-paper-on-organic-light-emitting-diode-oled-IJERTCONV4IS32004.pdf>. – Date of access: 19.03.2024
4. Organic Light Emitting Diodes (OLEDs) [Electronic resource]. – Mode of access: https://link.springer.com/referenceworkentry/10.1007/978-3-540-79567-4_79. – Date of access: 20.03.2024
5. Brighter Than Ever: The Secret Behind Next-Gen OLED Technology [Electronic resource]. – Mode of access: <https://scitechdaily.com/brighter-than-ever-the-secret-behind-next-gen-oled-technology/>. – Date of access: 16.03.2024
6. Technological Advancements in OLED Microdisplays Propel Market Growth, Fueled by High-Resolution and Miniaturization Trends [Electronic resource]. – Mode of access: <https://www.prnewswire.com/news-releases/technological-advancements-in-oled-microdisplays-propel-market-growth-fueled-by-high-resolution-and-miniaturization-trends-301977211.html>. – Date of access: 15.03.2024
7. Exploring OLED display [Electronic resource]. – Mode of access: <https://riverdi.com/blog/exploring-oled-display-advantages-and-applications>. – Date of access: 14.03.2024