## 2-5. Photofunctional Materials

### Overview

Photofunctional materials are materials that exhibit specific functions in response to light, and they are applied across a wide range of fields including energy, information and communication, environment, and medicine. By utilizing properties such as light absorption, emission, reflection, and refraction, various technologies have been developed, including recording media, luminescent materials, optical sensors, displays, solar cells, and photocatalysts. Especially since the beginning of the 21st century, numerous applications have emerged. Through the design of molecular and nanostructures, it has become possible to precisely control light behavior depending on its wavelength and intensity. As a result, photofunctional materials are expected to remain a crucial class of materials in fields such as environmental science, energy, and healthcare.

In Japan, many researchers have led this field since the 1970s. In particular, photoresists have been regarded as essential materials for the miniaturization of semiconductors. For further details, refer to section "2-4. Photofunctional Materials" in the Photochemistry Div Report described in Japanese.
URL: https://division.csj.jp/div-report/02/0220400.pdf

### Current Status and Frontiers

Photofunctional materials are attracting increasing attention in various disciplines, including physics, chemistry, mathematics, biomedical materials, artificial intelligence, photonics, and engineering. Categories of photofunctional materials include photocatalytic materials, photoenergy conversion materials, photonic materials, plasmonic nanoparticle materials, and luminescent materials, which are classified separately.

This section on "Photofunctional Materials" covers the following 20 categories:

1. Optical Recording Materials, Heat Mode, and Photon Mode
2. Optical Recording Dyes
3. Organic EL
4. Design of Luminescent Molecules by Theoretical Calculations
5. Electrochemical Imaging (Electrochromism and Electrochemiluminescence)
6. Organic Photochromic Materials
7. Inorganic Photochromic Materials
8. Photoinduced Morphological Change and Surface Relief
9. Conversion to Mechanical Energy

10. Photomechanical Crystal Materials
11. Force-Sensitive Luminescent Probe
12. Photomagnetic Materials
13. Magneto-Optical Materials
14. Vapochromic Materials
15. Mechanochromic Materials
16. Photodetectors
17. Organic Chiral Materials
18. Inorganic Chiral Materials
19. Photoacid Generators
20. Light-Resistant Materials

Many of these research areas have advanced significantly since the beginning of the 21st century and are closely linked to developments in nanotechnology and materials science. In recent years, molecular-level design has become feasible, enabling the development of materials with more sophisticated functions such as light-triggered switching, self-healing, and energy conversion.

## References


1. K. Mizuno, H. Miyasaka, H. Ikeda (Eds.), "*Photochemistry Frontier: Fundamentals of Organic Photochemistry for Future Materials*" in Japanese, Kagaku Dojin (2018).
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3. Themed collection for "*Photofunctional Materials and Transformations*", L.-Z. Wu, *J. Mater. Chem. A*, **11**, 13063–13064 (2023).
4. Thematic issue for "*Organic Photofunctional Materials and Applications*" in *Dyes and Pigments*: https://www.sciencedirect.com/special-issue/10MWK2XJG42
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## Future Perspectives and Directions

Challenges to be addressed and goals to be achieved within the next 10 years: With the advancement of material design integrated with AI and machine learning, the automation of molecular design and improved accuracy in predicting structure–function relationships are anticipated. These developments are expected to lead to further enhancement and diversification of photofunctional materials. Moreover, by incorporating multiple light-responsive functions into a single material, applications in next-generation photonic devices and smart materials—characterized by multifunctionality and high integration—are expected to progress significantly.

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