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Sustainable Materials in Thin Film Technology: A Path Toward Circular Economy

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Abstract:

The transition toward sustainable materials in thin film technology represents a crucial step in achieving a circular economy. Thin films, widely utilized in photovoltaics, electronics, sensors, and coatings, traditionally rely on resource-intensive and non-recyclable materials. Recent advancements emphasize eco-friendly alternatives, such as biodegradable polymers, earth-abundant metal oxides, and organic-inorganic hybrid materials, which reduce environmental impact while maintaining high performance. Sustainable fabrication techniques, including low-temperature deposition, solvent-free processing, and material recycling, further enhance resource efficiency.

Integrating life cycle assessment (LCA) and green design principles enables the optimization of thin film production for minimal waste generation and energy consumption. This paper explores the potential of sustainable materials and processes in redefining thin film technology within the framework of the circular economy, highlighting innovations that foster material recovery, reuse, and long-term environmental resilience. The study underscores the pivotal role of sustainable thin films in advancing global green technology transitions.

Key Words: Sustainable Thin Films, Circular Economy, Eco-friendly Photovoltaic Materials, Recyclable Semiconductor Technology, Green Nanomaterials.

