Modern Approaches on Material Science
DOI: 10.32474/MAMS.2023.05.000212
ISSN: 2641-6921
Mini Review

Infrared Transparency Confronts New Challenges

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Received: August 30, 2023 **Published:** September 5, 2023

Introduction

In recent years, there has been a surge in interest and research focused on infrared optical thin films, crucial components within infrared optical systems. Extreme environmental factors such as aerodynamic heating, mechanical stresses, electromagnetic and laser interference, sand and rain erosion pose challenges like cracking, wrinkling, and delamination of these films. Such demanding conditions necessitate films with high surface hardness, stability, and adhesion. For multispectral optical transmissions, infrared films must have high transmittance in visible and far-infrared bands, tunability, and optical anti-reflection properties in specific wavelengths. Electromagnetic shielding demands superior electrical performance, while laser resistance requires rapid phase change capabilities. However, theoretical and experimental studies on infrared transparency in extreme environments are in the early stages. During high-speed flight, compressed air generates friction against the aircraft's surface, converting kinetic energy into heat, leading to a "window thermal barrier." Viscous interference affects aircraft surface pressure, impacting lift, drag, and stability and posing a risk to the infrared window. The complex electromagnetic environment in and around aircraft arises from natural and human-made sources, affecting infrared optoelectronic systems. Current enclosures lack radar stealth, allowing electromagnetic radiation to interfere with sensitive detectors alongside radar reflection signals due to multiple reflections.

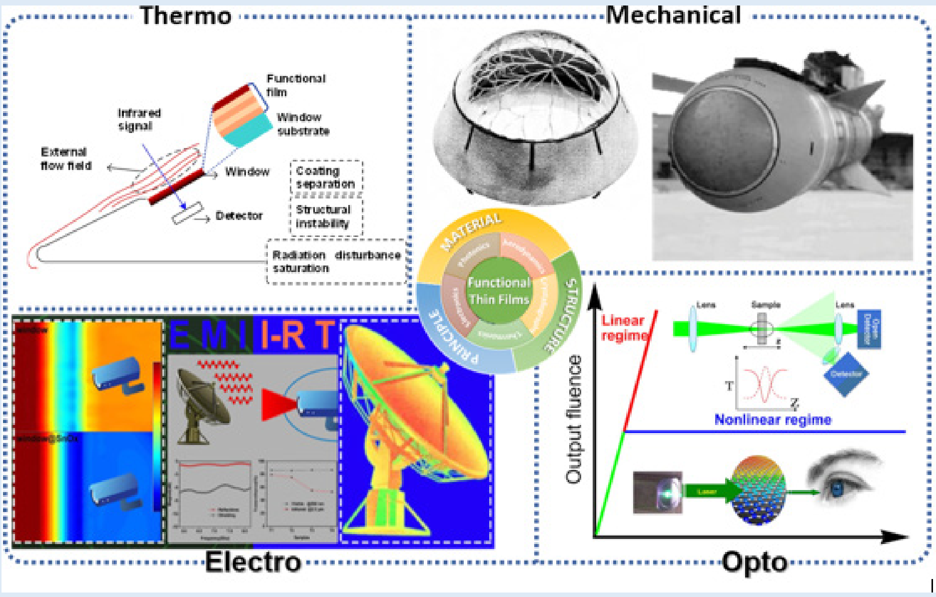

Figure 1: Table of Contents Graphic.

Sand and rain erosion occur when solid particles impact optical windows at high speeds during rain. This damages windows, reducing IR transmittance and material strength, affecting detection and guidance. Laser damage to thin films comes in thermal, mechanical, and radiation forms, risking human eyes, optoelectronic devices, and optical systems. Window materials need more than transparency; mechanical properties are vital for demanding environments. Yet, high hardness paradoxically decreases transparency. Balancing high transparency with low IR thermal radiation is challenging, as is balancing electrical conductivity and infrared transmittance due to carrier effects Figure 1. In conclusion, infrared transparency faces significant challenges due to extreme environmental conditions. Overcoming these demands innovation in materials, designs, and a comprehensive understanding of interactions between materials and environment.

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