

基于不匹配折射率的激光驱动木基散射体*

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摘 要:【目的】基于激光二极管的固态照明主要用于最先进的照明系统,其具有高功率密度、高亮度、小尺寸和低能耗的特性。然而,这些系统依赖于光转换无机荧光粉,不仅制造条件复杂且不可持续。此外,即使在高电流密度下,集成的照明系统依然存在光量子转换效率低的问题,严重限制了它们在汽车前灯、投影显示器和泛光灯投影仪等高亮度领域的应用。【方法】为了解决固态照明用散射体存在的低量子效率、制备工艺复杂、不可持续等问题,提出了一种不匹配的折射率策略,通过简单的脱木质素和聚合物(聚乙二醇二丙烯酸酯)浸渍方法,直接将天然木材转化为激光驱动の木基散射体。【结果】以轻木、泡桐、杉木、杨木等不同密度的天然木材通过不匹配的折射率策略成功制备了六种木基散射体。通过改变天然木材的密度来优化激光驱动木基散射体的光学性能,这有助于调整光扩散特性。最优的 $0.12 \text{ g} \cdot \text{cm}^{-3}$ 木基散射体获得几乎均匀和各向同性的光照度分布,其最佳照度变化系数低至 17.7%,显著低于商用散射体。 $0.12 \text{ g} \cdot \text{cm}^{-3}$ 木基散射体的照度均匀度大于 0.9,明显高于室内工作场所照明的 ISO 要求。最优的木基散射体的激光损伤阈值为 $7.9 \text{ J} \cdot \text{cm}^{-2}$,远高于市售荧光粉衬底的损伤阈值。此外,优化后的木基散射体还具有出色的机械性能、优异的热稳定性、对恶劣环境条件的耐受性和低散斑对比度。【结论】这些结果表明,激光驱动の木基散射体是一种有前途的激光颜色转换器,适用于室内、远距离室外、海底等高亮度激光照明应用。

关键词: 固态照明; 不匹配折射率; 天然木材; 激光驱动木基散射体;

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A laser-driven diffuser based on mismatched refractive index*

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Abstract: 【Objective】 Laser-diode-based solid-state lighting is primarily used in state-of-the-art illumination systems with high power density, high brightness, small dimensions and low energy consumption. However, these systems rely on light-converting inorganic phosphors, which have complex manufacturing conditions and unsustainability. Moreover, integrated lighting systems still suffer from low light quantum conversion efficiencies in which they exhibit low quantum efficiency at high injection current densities. This limits their applications in high-brightness areas such as car headlights, projection displays, and floodlight projectors. 【Method】 In order to solve the problem of low quantum efficiency, complex manufacturing, and unsustainability of diffusers for solid-state lighting, a mismatched refractive index strategy is proposed to directly convert natural wood into laser-driven wood diffusers by a simple delignification and polymer (poly(ethylene glycol) diacrylate) impregnation method. 【Result】 Six wood diffusers were successfully prepared from natural wood with different densities, including balsa wood, paulownia wood, China fir wood, and poplar, by a mismatched refractive index strategy. The optical performance of the laser-driven wood diffuser is optimized by changing the density of natural wood, which helped adjust the light diffusion characteristics. The optimal $0.12 \text{ g} \cdot \text{cm}^{-3}$ Laser-driven wood diffuser obtained almost homogeneous and isotropic light illumination. The optimal coefficient of illuminance variation of the wood diffuser is as low as 17.7%, which is significantly lower than that of commercial diffusers. The illuminance uniformity is larger than 0.9, which is significantly higher than the ISO requirements for indoor workplace lighting. The laser

damage threshold is $7.9 \text{ J} \cdot \text{cm}^{-2}$, which is considerably higher than those of the substrates of commercially available phosphors. Furthermore, the optimized wood diffuser exhibits outstanding mechanical properties, excellent thermal stability, tolerance to harsh environmental conditions, and low speckle contrast. 【Conclusion】 These results show that the laser-driven wood diffuser is a promising laser-color converter that is suitable for indoor, long-distance outdoor, undersea, and other high-luminance laser lighting applications.

Key words: Solid-state lighting; Mismatched refractive index; natural wood; Laser-driven wood diffuser;

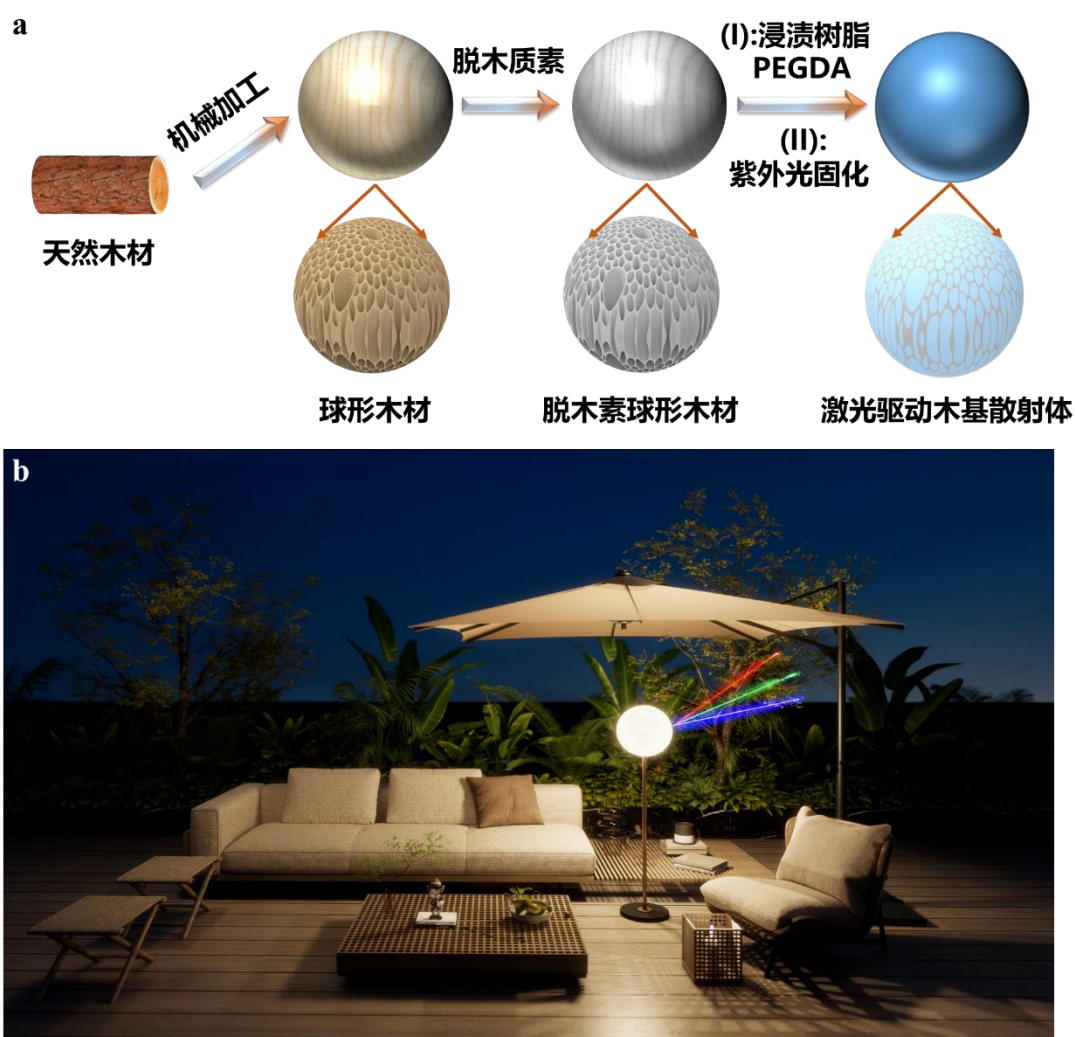


图1 a)激光驱动木基散射体的制备过程。b)利用木基散射体与红+绿+蓝激光系统相结合产生白光以及照明应用演示