Nanoroughness Induced Anti-Reflection and Haze Effects in Opaque Systems

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How to make a material anti-reflective without changing its high refraction index? Achieving anti-reflection in high-refractive-index materials poses challenges due to their high reflectivity (Fresnel equations). Based on theory with new boundary conditions, we propose modifying surface properties on a nanoscale to tackle this. Our study on weakly rough opaque surfaces reveals significant changes in specular and diffuse scattering, predicting anti-reflection where roughness matches light penetration depth for the first time. Experimental validation on nano-roughened Si films (at wavelengths 300-400 nm) supports our findings. We also analyze angular and polarization dependences of nanoroughness-induced haze, showing predominant p-polarization and minimal haze at nanoscale, yet impactful specular reflection reduction.

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