Natural biological structures, in particular, moth’s eye and lotus leaf were the inspirations for the formation of atomically bonded, optical-quality, nano-textured thin glass film coatings on glass plates that embody multifunctional performance characteristics. The coatings comprise an interconnected network of nanoscale pores surrounded by a nanostructured silica framework. These structures result from a novel fabrication method that utilizes metastable spinodal phase separation in low-alkali borosilicate glass materials. The approach not only enables design of surface microstructures with graded-index antireflection characteristics, where the surface reflection is suppressed through optical impedance matching between interfaces, but also facilitates self-cleaning (superhydrophobic), antifingerprint as well as omniphobic functionalities abilities through various modifications of the surface chemistry. Based on near complete elimination of Fresnel reflections through a single-side coated glass and corresponding increase in broadband transmission, the fabricated nanostructured surfaces are demonstrated to promote an invaluable ~ 3-7% relative increase in current output of multiple direct/indirect bandgap photovoltaic cells, while preventing dust/pollution accumulation. Moreover, as formed these coatings are structurally superhydrophilic (i.e., display anti-fogging functionality) and demonstrate superior resistance against mechanical wear/abrasion and can be engineered to block UV-radiation. With demonstrated scalable and manufacturable formulations, providing an all-in-one combination of multiple salient and unique performance enhancers, our approach holds significant potential for solar panels, lenses, detectors, architectural windows, optical components used in weapons systems and in many other products.

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