

# LIGHT-ABSORBING COATINGS FOR HIGH REFRACTIVE INDEX OPTICS

## High RI Optical Black (IOB)

High refractive index substrates are used in a multitude of optical applications like AR/MR glasses, AR HUDs, camera lenses, prisms, and optical sensors. External or internal light source may unintentionally illuminate the substrate edges potentially leading to unwanted reflections within the substrate. The reflected light may significantly deteriorate the performance of the optical devices.

Traditionally this phenomenon is countered by using black coating at the substrate edges to absorb the unwanted reflections. This approach does not consider the refractive index difference between the black coating material and the substrate. Combining both, high optical density and the index matching high refractive index, the unwanted reflections are effectively eliminated.

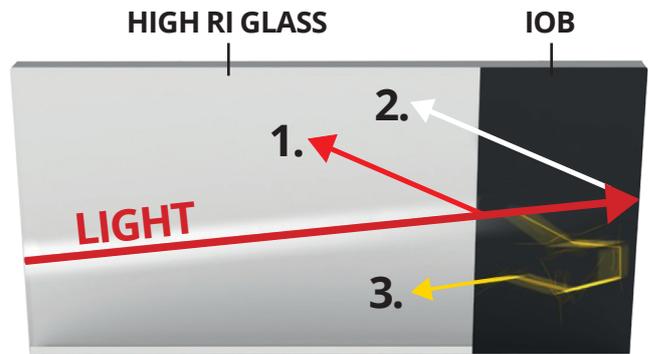


Figure 1. Reflection at the edge of the high index substrate. (1.) Reflection due to index mis-match. (2.) Reflected light at interface of the black material and air. (3.) Scattered light. Optimized index matching black with high optical density eliminates all 3 components.

## Eliminating the reflections

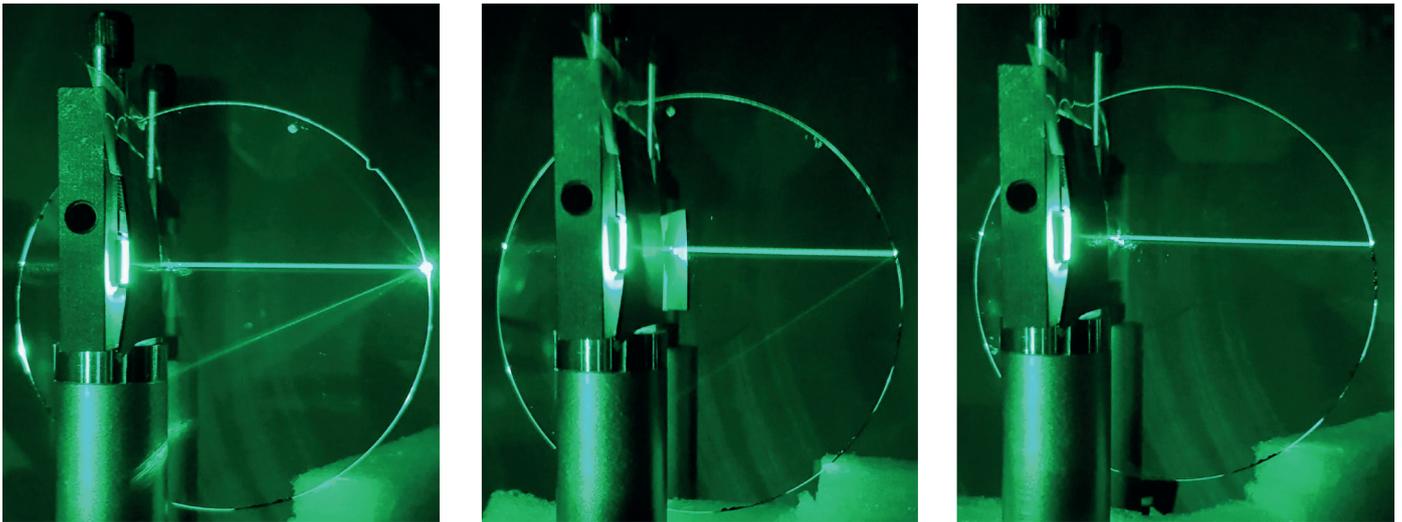


Figure 2. (Left) 1.9 RI substrate without black edge coating, a clear reflection (10%) seen. (Middle) 1.9 substrate with 1.5 RI black material with still visible reflection (3%). (Right) 1.9 RI index matching black material with no visible reflection.

Tests performed with green laser and high index wafer demonstrate how the black index matching material eliminates the reflections (Figure 2.). Substrate has refractive index of 1.9. Image on left shows how the laser beam is reflected from the edge of the substrate when

no black coating is used (Index difference 0.9). Image in the middle shows the situation with black coating but with non-matching refractive index (RI  $\Delta$  0.4). Visible 3 % reflection is seen. Finally, when index matching black is used there is no visible sign of reflection.

## IOB – High Index Optical Black Products

### Optical density and thickness

Portfolio of IOB products covers the whole index range from 1.6 to 1.9x. The index values (RI) listed in Table 1. are nominal values - the products can be formulated to meet the specific index targets. Typically, there are also specific requirements for optical density (OD) and thickness. Custom formulations are possible so that the thickness and optical density requirements can be met. Figure 3 illustrates the relationship of optical density and thickness of a version of IOB-190.

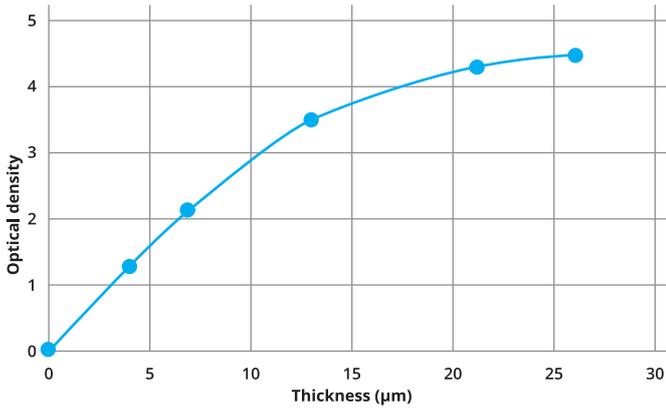


Figure 3. Optical density of IOB-190 in function of thickness.

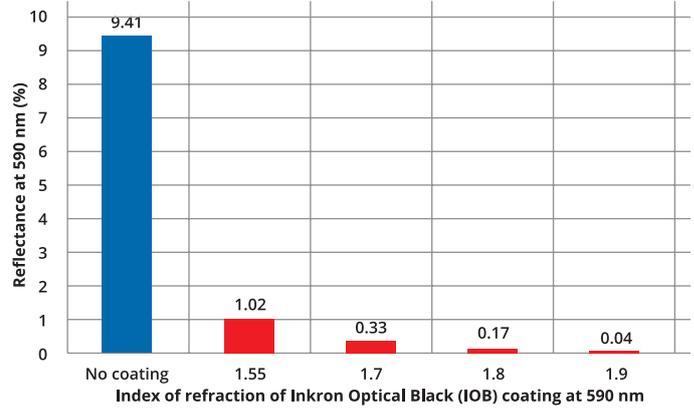


Figure 4. Diminishing reflection achieved by index matching of substrate and black edge coating. The RI of black coating material is adjusted to meet the RI of the RI 1.9 glass substrate Measurements at 590 nm.

### Processing

Typical coating methods for the IOB materials are dispensing, jetting or roll coating methods. There is both thermally and UV curable IOB versions available where the thermal IOB materials are solvent based and UV curable materials are solvent free and don't require extra heating steps to cure the materials. Standard IOB products can be seen in Table 1.

Product	RI	Viscosity (mPas)	Curing	Optical Density (OD)	Note
IOB-160	1.6	100	Thermal/IR	> 4 @ 20µm	Solvent based
IOB-170	1.7	150	Thermal/IR	> 4 @ 20µm	Solvent based
IOB-180	1.8	200	Thermal/IR	> 4 @ 20µm	Solvent based
IOB-190	1.9	250	Thermal/IR	> 4 @ 20µm	Solvent based
IOB-180-UV-20	1.8	2000	UV-LED	> 2 @ 20µm	Solvent free
IOB-180-UV-100	1.8	1200	UV-LED	> 2 @ 100µm	Solvent free
IOB-190-UV-20	1.9	1800	UV-LED	> 2 @ 20µm	Solvent free
IOB-190-UV-100	1.9	1200	UV-LED	> 2 @ 100µm	Solvent free

Table 1. Nominal refractive index of Inkron's Optical Black (IOB) materials.

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Inkron, a member of Nagase Group, is an expert in optics processes and manufacturer of the critical materials and coatings. Targeted applications of Wafer Level Optics (WLO) include Diffractive Optics Elements (DOE) e.g. waveguides for XR devices, optical diffusers and LIDAR components. These industry-leading optical coatings cover refractive index range of 1.1 - 2.0 with state-of-the-art nanoscale processing capabilities.

Other material solutions Inkron provides are patent pending high index optical black, adhesion promoters and optical adhesives. Inkron's material expertise and facilities of Nanoimprint Lithography (NIL) create opportunities to optimize and fine-tune the optics manufacturing processes.