BUSINESS UNIT
PVD- AND NANOTECHNOLOGY

ENHANCED TRANSPORTATION SAFETY WITH ANTI-REFLECTIVE COATINGS

THE TASK

Light reflected on glass surfaces can carry serious safety risks in transportation on the street. The windshields of transit and city buses are particularly affected. The vertical windshield installation in conjunction with the interior illumination obscures the driver's vision and creates hazardous situations which can lead to accidents. In the United States of America alone, there are 25,000 to 30,000 injuries every year in accidents involving buses, about 1 percent of which are fatal.

Reflections occur if light is mirrored at the interfaces of media with various refraction indices. Air has a refraction index (n) of approximately 1 in comparison to 1.5 for glass.

By applying thin coatings additional interfaces can be created which may result in phase shift and attenuation or extinguishing of optical waves. Application-related anti-reflective (AR) coatings can be generated based on intentional modification of refractive index and coating thickness.

OUR SOLUTION

Conventional anti-reflective coatings, such as for optical filters, often consist of complex multilayer coating systems. The Fraunhofer USA Center for Coatings and Diamond Technologies (CCD) collaborated with a company in Grand Rapids, Michigan, USA, to develop a more simple and economic thin film stack solution.

The coating concept is based on minimizing glare in the mean wavelength range of visible light (550 nm). For minimal reflection, the coating must have an average refractive index between the adjacent media.

$$n_{AR} = \sqrt{(n_{Medium\ 1} \times n_{Medium\ 2})}$$

The glass-air transition requires a refractive index of less than 1.3. This value can only be achieved by salts which are not suitable as durable thin film coatings. For that reason, a layer with a refractive index greater than that of glass is used as interlayer, followed by a second layer with a medium index to air. The coating system developed at the CCD is based on this approach using aluminum oxide (Al_2O_3, n ~ 1.7) and indium-stannic (ITO, n ~ 2.0) for an incremental increase of the refractive index, followed by a fluorinated diamond-like anti-reflective carbon coating (F-DLC, n ~ 1.4).

Conventional coating techniques were used with the goal of scalability to windshield application. Both metal oxides were produced by means of pulsed DC magnetron sputtering. Aluminum oxide Al_2O_3 was reactively deposited from a metal target (99.99 percent Al), whereas ITO was deposited from a ceramic target (In_2O_3/SnO_2 90/10 weight percent). The F-DLC coatings were generated with a gas mixture of Ar, C_2H_2, H_2 and CF_4 from a linear ion source.

RESULTS

The development of the anti-reflective coating concept based on F-DLC and metal oxides was funded by the Department of Transportation of the USA within a program for small and medium-sized companies. Reflection and transmission of the windshield glass segments coated at the Fraunhofer CCD were measured at the Transportation Research Institute of the University of Michigan (UMTRI).

Portions of reflected (top) and transmitted (bottom) irradiation windshield pane glass, with/without anti-reflective coating

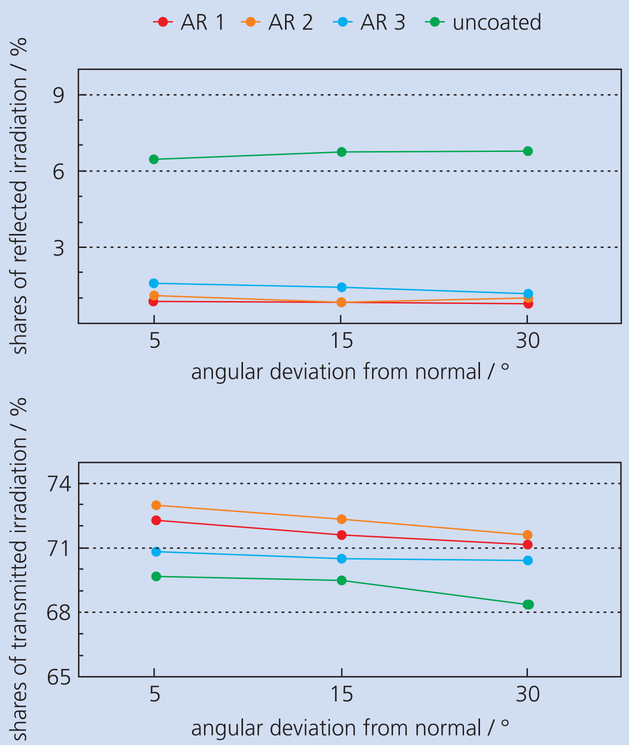

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Figure 2 demonstrates the anti-reflective coating effect with a pane glass coated on one half. The glare from solar radiation is drastically reduced and the details behind the coated half are significantly more visible.

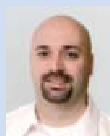
The measurements of UMTRI were performed in a dark room using an electric light source. The data were recorded at angles of 5 °, 15 ° and 30 ° to the normal incident to simulate the field of view of the bus driver under realistic conditions. Coating the windshield with F-DLC reduced reflection from almost 7 percent to less than 1 percent (see Fig. 3, top).

At the same time the transparency of the windshield glass was not affected by the thin film coatings (see Fig. 3, bottom). In fact, a slight increase in transparency was noted, which is due to the decreased refraction. When applied to automotive windshields these coatings increase the driver's visibility by at least 10 m, helping him to detect hazards and avoiding accidents.

1 Reduced vision due to reflection on the windshield

2 AR coated glass pane, coated on the right half (left side uncoated)

CONTACT



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