Kodaikanal Obs.Bull.(1991) 11, 77-80

A Sol-Gel Derived AR coating on Ophthalmic Lenses in the Visible Region

P.K.Biswas, A.K.Atta and D.Ganguli
Central Glass and Ceramic Research Institute
Calcutta 700 032

Abstract

Deposition of antireflective coating in the visible region by the sol-gel spinning technique has been described in this communication. A 2-layer design, centred at 550 nm, was used. The design can be denoted as Glass/H/L/Air where H and L signify layers of ZrO_2 and SiO_2 respectively, having optical thicknesses in units of $\lambda_{0/4}$. The thicknesses were controlled by varying the concentrations of equivalent metal oxides in the prepared sols, and controlling the spinning rates. The deposition of films was carried out on both sides of ophthalmic lenses by the spinning technique followed by baking at 500^0c for 15 min. The transmission was found to be 99.7 ±0.1% in the wavelength region 525-575 nm.

Key words: sol-gel, antireflection coating, ophthalmic lens

Introduction

Antireflection coatings are commercially applied on different optical and electro-optical components for the reduction of unwanted surface reflection by various techniques e.g.CVD, PVD, Sol-gel etc. Various advantages of the sol-gel technique for the deposition of optical coatings on glass and other substrates are now well known and the preparative conditions for single or multilayer antireflection coatings by this technique has been widely studied (Brinker & Harrington 1981; Yoldas & O'Keeffe 1979; Mukherjee 1981; Thomas 1986; Debsikdar 1987; Phillips & Dodds 1981; Dislich & Hussmann 1981; Biswas, Kundu & Ganguli 1989). There is, however, apparently no published account of the preparation of AR coatings on ophthalmic lenses by the sol-gel technique. The present report is a preliminary account of such a coating system and procedure.

ZrO_2 system

ZrO_2 coating was prepared by dissolving an inorganic zirconium salt in a mixed alcoholic solvent and stirred for 15 min. Next, the required quantity of mineral acid was added followed by the addition of a complexing agent and the resulting solution stirred for one hour or more. The solution was aged for 24 hours to make it ready for coating operation.

SiO_2 system

The starting sol for SiO_2 coating was prepared by mixing silicon alkoxide and alcohol and addition of water under stirring. The reaction was catalysed with HCl. The stirring of the sol was continued for 1.5h and diluted with the alcohol to get the required concentration (4-6 wt % equivalent SiO_2) and stirred for 2h more and aged for a few hours and used for coating.

Preparation of coatings

Ophthalmic lenses were thoroughly cleaned with liquid detergent followed by acid and water. Next, the lenses were cleaned ultrasonically. The dried lenses were coated on both sides with the sols by the spinning technique at a suitable rpm. The film was then baked to 500^0 C with 15 min soaking for obtaining hard, transparent oxide coatings. The whole operation was made in a relatively dust-free atmosphere.

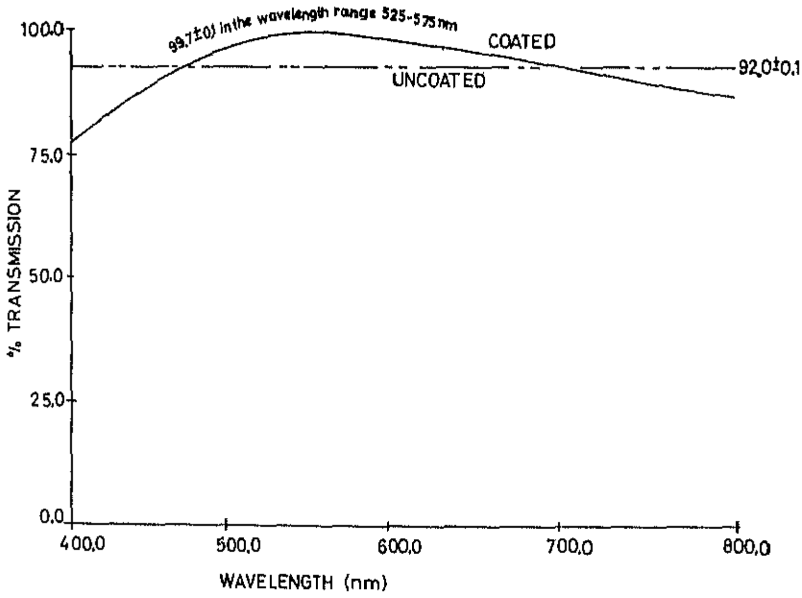

Figure 1. Trasmission spectra in the visible range for an uncoated and an AR coated ophthalmic lenses.

Results and Discussion

Antireflective coatings on ophthalmic lenses are now a mass-consumed commodity in some countries because of their cosmetic effect. They are usually prepared by the vacuum technique, and no published account is available on the problems and prospects of sol-gel AR coatings on ophthalmic lenses.

Fig. 1 shows the transmission pattern in the visible range for an AR coated (both sides ; $\lambda_0 = 550$ nm) ophthalmic lens. The transmission of the lens comes to about 99.7 ± 0.1% in the wavelength region 525-575 nm while the transmission of the uncoated lens is about 92.0 ± 0.1% in the visible range. The simple design used for obtaining the spectrum was GHL, where G = glass, H = high index layer (ZrO_2) and L = low index layer (SiO_2). Both the H and L layers had an optical thickness of $\lambda_0/4$ where $\lambda_0 = 550$ nm.

It should be noted that the coated ophthalmic lens, being a curved surface, exhibits quite high percentage transmission (99.7 ± 0.1) although oblique incidence would occur leading to splitting into the p and s components that should give rise to relatively high reflection. It seems that the obliquity effects in lenses comprise an optical system of spherical and planar surfaces (Knittl 1976). Hence to minimise the reflection the desired optical thickness for a planar system would satisfy for the spherical system provided a detuning takes place for the obliquity as one cannot obtain perfectly uniform coating (Knittl 1976) on curved surfaces. The transmission spectra indicate that in this case the nominal thickness was probably obtained in one zone and the other zones were necessarily mismatched, resulting in the required overall detuning causing maximum transmission.

Problems of sol-gel spin coating

The main problem in the preparation of spin coatings by the sol-gel process is the formation of the so-called "trouble zone" along the circular periphery of the substrate. The width of this zone (1-2 mm) increases with decreasing spinning rate and with increasing sol concentration. Moreover, very fine spots are generated in the case of multilayer coatings because such defect zones with alternate layers of different materials of high and low refractive indices experience strong mismatch in thermal behaviour and become sources of crack generation. A necessary balance must therefore be struck between the sol characteristics and the spinning parameters so as to obtain defect-free coatings.

Acknowledgements

The authors are thankful to Dr.B.K.Sarkar, Director of C.G. & C.R.I. for permission to present this poster paper.

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