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ARVO Annual Meeting Abstract | May 2004

ACCURACY AND POSSIBILITIES FOR EVALUATING THE LENS GRADIENT–INDEX USING A RAY TRACING TOMOGRAPHY GLOBAL OPTIMIZATION STRATEGY

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Investigative Ophthalmology & Visual Science May 2004, Vol.45, 1723. doi:

Abstract

Abstract: : **Purpose:** The human crystalline lens is known to have a gradient refractive index distribution (GRIN). We studied the use of an *in vitro,* non–destructive technique based on an optical experimental set up with laser ray tracing and use of global optimization algorithms. The possibilities and accuracy of the technique is studied by evaluating the reconstruction of the GRIN distribution of a glass lens with a known GRIN profile. **Methods:** The experimental method uses a laser scanning system, two CCD cameras, and a glass chamber in which the lens is placed. A 0.5 mm diameter laser beam is scanned parallel to the optical axis at multiple entrance positions over the lens, and the refracted ray trajectories are recorded by the cameras. The measured slopes of the ray trajectories are the experimental data used for the optimization procedure. This procedure uses global search optimization routines, implemented in an optical design program (Zemax). The method starts with a priori assumptions about the GRIN model and uses the experimental data to find the best solution for the unknown GRIN distribution. The global procedure was tested on a commercial glass gradient index lens (GBX–25–40, GRADIUM, LightPath Technologies) with a known GRIN profile described by an 11th order polynomial. The accuracy in the GRIN reconstruction was evaluated optically using wave aberration analysis. **Results:** The theoretical accuracy of the optimization routine on the GRIN profile reconstruction, excluding experimental error, is limited by a mean absolute error of 0.0024±0.0022 with respect the nominal profile. However the error increases, for the real experimental data, to 0.041±0.017. These errors result in a mean standard deviation error of the coefficients of the wave aberration of 0.00021 μm and 0.014621 μm with and without experimental error respectively. **Conclusions:** Global optimization is a robust procedure for evaluating the GRIN with models involving a large number of parameters in the absence of experimental errors. However with real experimental data, the error in the reconstruction increases significantly due to the *ill–conditioned* nature of the optimization. Practical implementation of this technique in real crystalline lenses will require significant reduction of experimental errors and realistic assumptions of the actual GRIN distribution.

Keywords: optical properties • crystallins • computational modeling