

Geometrical analysis of third-order aberrations for a solid immersion lens

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Abstract: This paper gives a treatment for finding 3rd order aberrations in solid-immersion lenses (SILs) using spherical-aberration as the basis for a polynomial power expansion of the wavefront. Unlike previous work, the treatment is general for any incident and lens media, for any lens thickness, and for any chief-ray specification. Using this treatment, a tolerance analysis is given with emphasis on thickness tolerance and limitations on field of view. Major findings include tight thickness tolerance for high-index hyperhemispheres and a tolerance window for hemispheres centered about a thickness less than the radius of curvature of the lens.

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References and links

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1. Introduction

Optical resolution can be greatly enhanced by use of a solid immersion lens (SIL). A SIL reduces the wavelength of light inside the optically dense medium of the lens and, as a result, reduces the focused spot size, $s = \lambda / (n \sin \theta)$, where λ is the wavelength in vacuum, n is the index of the SIL, and θ is the marginal ray angle inside the SIL. First investigated by Mansfield and Kino in 1990 [1], SILs have since found use in many applications where increased resolution is desired, such as data storage and lithography [2]. Since a SIL acts as a single refracting surface, the paraxial aberrations introduced by the lens have simple geometric relationships. The following sections investigate the 3rd order aberrations for a single refracting surface and their implications for fabrication and usage of SILs.