

High aperture focusing through a spherical interface: application to solid immersion lens (SIL) for subsurface imaging

S.H. Goh¹, C. J. R. Sheppard^{2,3}

¹Department of Electrical and Computer Engineering, National University of Singapore

²Bioimaging Laboratory, Div of Bioengineering, National University of Singapore, Singapore 117574

³Department of Diagnostic Radiology, National University of Singapore, Singapore

Email: colin@nus.edu.sg

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The solid immersion lens (SIL) was proposed in the 1990s. There are two configurations depending on the position of the imaging plane. SIL has applications in optical data storage, and semiconductor integrated circuit inspection. A hemispherical SIL has its imaging plane at the centre of the sphere with the light travelling normal to the interface. The aplanatic SIL has its imaging plane at a distance of radius/refractive index away from the centre of the sphere. Both these locations give aberration-free imaging. Subsurface imaging is possible in both configurations with careful designing.

We extend the high aperture diffraction calculation of the field in the focal region for focusing through a dielectric interface to the case of a spherical interface. The wave-front aberration vanishes for both the central and aplanatic cases, resulting in a spatial resolution of about $0.2\mu\text{m}$ in Si for a wavelength of 1340nm . For other axial positions of the imaging plane, spherical aberration of different orders is introduced. We find that a spatial resolution of about $0.33\mu\text{m}$ can be achieved over a wide range of imaging depths.

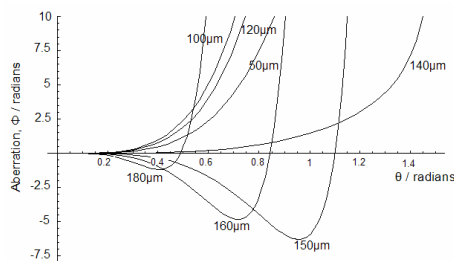


Fig 1 Wave aberration as a function of θ for different imaging planes for a 1mm diameter sphere

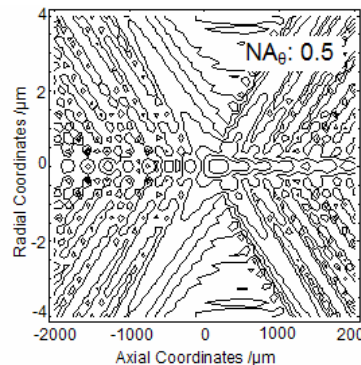


Fig 2 Contours of constant intensity in the x - z plane for an object plane $\Delta_u = 160\mu\text{m}$. Spherical radius = $500\mu\text{m}$

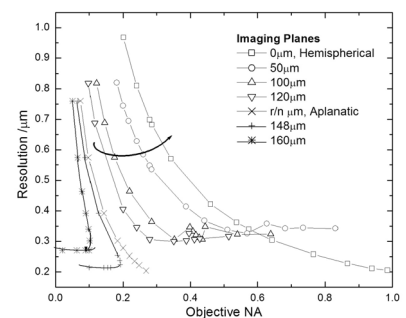


Fig 3 Change in spatial resolution with objective NA at different object planes.

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