Imaging with annular focusing through a dielectric interface

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In ray optics, it is a well-known fact that there exist two aplanatic points of a sphere. Focusing light into these aplanatic points will give a free-aberration focal field distribution. Based on this fact, solid immersion microscopy (SIM) has been proposed and developed in the last three decades[1, 2]. Due to its ability in providing high resolution and optical collection efficiency, the technique has been employed in a number of applications like lithography, optical data storage, biological imaging, and especially in integrated-circuit failure analysis.

It is also well-known that using a simple annular filter (AF) can improve resolution of a microscope. Hence, it is not surprising that there are efforts in integrating the AF and the SIM for achieving a high resolution image [3]. Here we study the integration both theoretically and experimentally. Theoretically, some researchers used the diffraction integrals for studying the integration [4]. Recently, we derived a rigorous analytical model for studying the focusing system [5]. In this presentation, we show that the diffraction integrals may not be appropriate for investigating the integration in the case of a high blocking angle of the AF. We also show that the aplanatic points do not exist under some circumstances. Experimentally, we manipulate the AF and polarization of light to resolve gratings consisting of 120-nm-wide lines, spaced 120 nm apart using 1342nm wavelength laser. Our experimental setup is shown in Fig. 1(a). Figure 1(b) shows the best image which we obtained without the filter. By introducing the AF to block a beam with a diameter of 6.2mm, we could improve the resolution significantly as shown in Fig. 1(c).

![Experimental Setup](image1)

(a) Experimental Setup

![Image 2](image2)

(b) No Filter

![Image 3](image3)

(c) 4mm Filter

Figure 1: Imaging with linear polarization and annular filter.

REFERENCES