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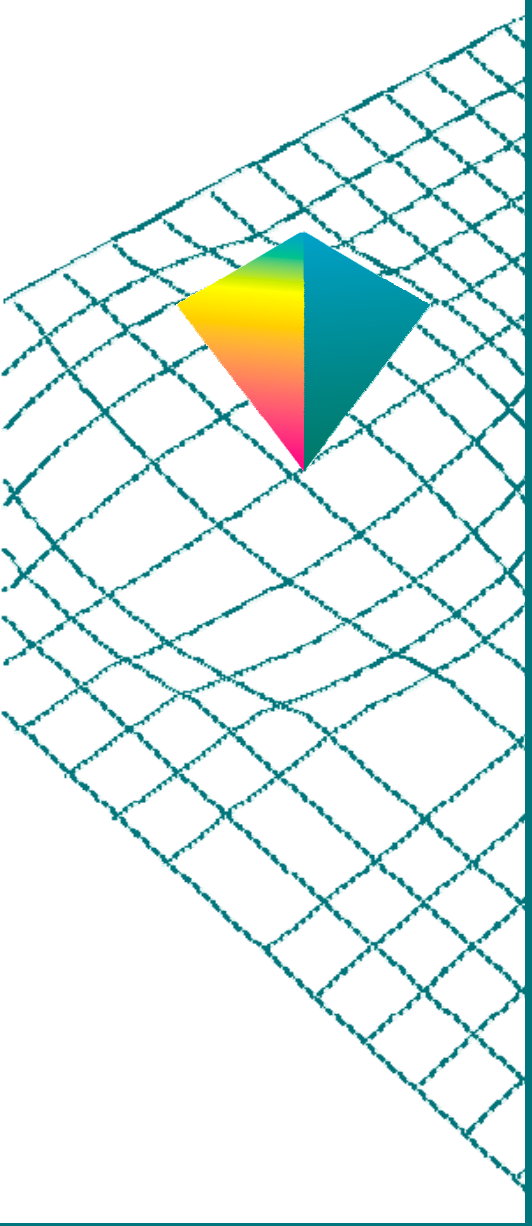

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M. Amberg / S. Sinzinger

Efficient Coupling Mechanisms for Planar Integrated Free Space Optical Systems

ABSTRACT

Planar integrated free space optics (PIFSO) is a promising approach to microoptical systems integration. Due to the diffractive implementation the system's efficiency is rather low. By using refractive prisms for coupling it is possible to raise the overall efficiency.

MOTIVATION AND BASICS

A planar integrated free space optical system [1] is a system combining the advantages of classical free space optical systems and the precise fabrication and alignment possibilities of mask lithography. The idea is to fold a free space optical system into a thick glass substrate by placing reflective diffractive optical elements (e.g. lenses, beamsplitters or gratings) on the surfaces of the substrate. Thus the light travels on a zigzag-path through the substrate. Such optical systems with good optical properties have been demonstrated for a variety of applications like optical interconnects or security applications [2,3]. But due to limitations of the minimum feature size of the lithographic fabrication (e.g. 1µm for mask lithography) the use of diffractive optical elements results in the trade-off between efficiency and optical functionality of these systems. Within this paper we show that it is possible to raise the overall systems efficiency without the need to switch to more expensive technologies like e-beam writing by using refractive prisms for coupling.

COUPLING MECHANISMS

Figure 1 shows the different coupling mechanisms for PIFSO-systems we are considering in this paper. Up to now, grating coupling is the low efficient standard coupling mechanism for such systems (fig. 1a and 2a) and the main cause for their low efficiency. The deflecting gratings are generally implemented as two phase level elements with an efficiency as low as 0.40. For a 4f setup [4] thus the overall efficiency is 0.075 due to seven reflections ($\eta_{reflection} = 0.95$) and two diffractive lenses ($\eta_{lens} = 0.81$) for imaging. Switching to a wedge coupled system the efficiency can be increased to app. 0.46 but the imaging quality is getter worse (fig. 1b and 2b). This is the result of the different optical path lengths introduced by the

wedges. This problem can be reduced by combining wedge and grating coupling. Compared to the grating coupled system more efficient four phase level gratings can be used since part of the deflection is introduced by the wedges. As seen in fig. 2c the imaging quality is improved significantly and the system's efficiency is now app. 0.24. This results from the additional gratings and the third diffractive lens (DOE 2) necessary for good imaging quality. This configuration is suitable to image the object field with good optical properties. Both systems, using a wedge for coupling, show very good imaging quality along a line in x-direction (see fig 2b and 2c). Compared to a purely diffractive system this is also true for the presence of thickness variations. In this case the y-position of the object-image pair which is image with good optical quality is varying.

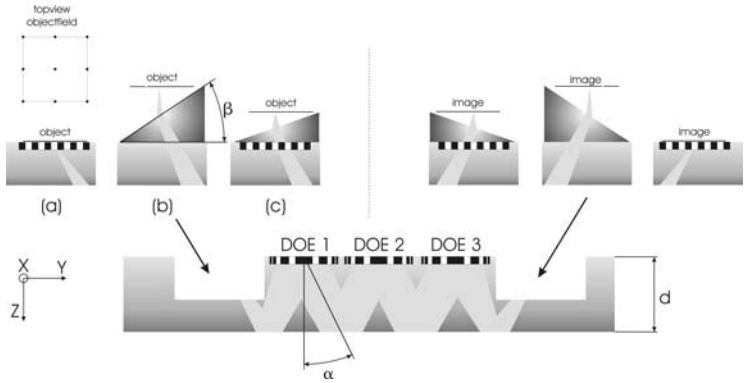

Figure 1: Coupling mechanisms for PIFSO systems a) grating coupling b) wedge coupling and c) combined wedge grating coupling

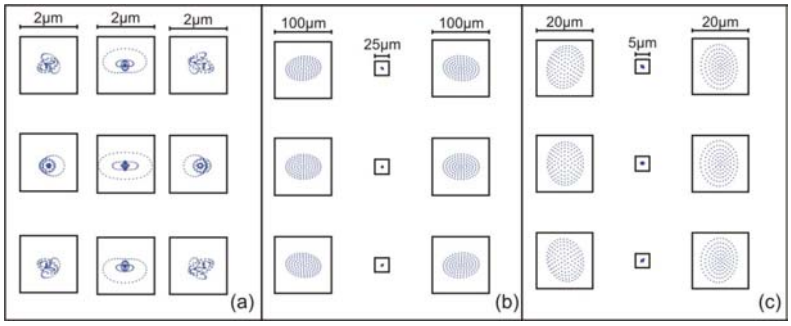

Figure 2: Spot diagrams for different coupling mechanisms systems a) grating coupling b) wedge coupling and c) combined wedge grating coupling

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