CHAPTER - IV

4.1 Introduction

The aim of this chapter is to present the system interfaces, the system object, and the system environment. The system interface is the interface between the system and the environment. The system object is the object that the system interfaces, and the system environment is the environment in which the system operates.

4.2 Proposed Work

PROPOSED WORK
CHAPTER - IV
PROPOSED WORK

4.1 Introduction

The goal of most optical design projects is to assemble an optical system that performs a certain task to a specified degree of accuracy. Usually, the goal is to form an image, i.e., a distribution of light that "resembles" some object. A necessary part of this process is determining how closely this goal has been achieved. Alternatively, you may have assembled two (or more) different systems and be forced to answer the question: which is better, system A or system B (or C, etc.). Obviously, we need some way to quantitatively assess the optical performance of a lens. It is unrealistic to be forced to formulate a different figure of merit for every conceivable object of which one might wish to form an image. Fortunately, we can think of an arbitrary object as a collection of simple objects: points, lines, edges, etc. The image evaluation techniques discussed in this chapter are all based on looking at the image of one of these "primitive" objects. These objects are simple enough to allow us to analyze their imagery in great detail and also provide insight into the imaging of more complex objects[1].

4.2 Coupling of LD-SMF’s

Recent progress in the low-loss and low-dispersion single-mode optical fibers in the 1-1.6 μm wavelength region has generated requirement for a
highly efficient and stable laser diode module. Reduction of the coupling loss between a semiconductor laser (LD) and a single mode fiber (SMF) directly increases the repeaters spacing in long-haul and submarine transmission system[2,3]. The laser-light power that can be launched into the SMF by using simple Butt joints method is small, typically of the order of 7-11 dB[4,5]. This is because of the mode mismatch (i.e., different spot size) between LD and SMF. Hence, for high coupling efficiency, the elliptically LD mode must be transformed to match that of circular SMF. This can be achieved by using a lensing scheme. Many lensing schemes for this mode matching have been reported in literature[6-18]. Table 4.1 summarizes some of the recent work together with reported lowest coupling loss. Usually a precise alignment of laser, lens and SMF is required for the coupling loss to be reduced.

4.3 Modern Lens design

Computer design of optical systems provides considerable scope for research into synthesis, analysis and correction of the systems. In this process of continually improving methods of design, scientists and engineers were working to found a novel forms of systems with greatly improved performance and yet with market simplicity. These two characteristics of optical system must always be considered jointly in assessing progress, and it is in this area that the skills of optical design, particularly of synthesis, persist.
Table 4.1. Various methods of Laser Diode to Fiber coupling together with the corresponding lowest coupling loss

<table>
<thead>
<tr>
<th>Various Method</th>
<th>Types of fiber</th>
<th>Laser [(\lambda (\mu m))] used</th>
<th>Lowest coupling loss (dB)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photolithographic</td>
<td>SMF</td>
<td>GaAs [0.9]</td>
<td>4.7-6.4</td>
<td>[6]</td>
</tr>
<tr>
<td>Photolithographic</td>
<td>SMF</td>
<td>He-Ne [0.63]</td>
<td>-</td>
<td>[7]</td>
</tr>
<tr>
<td>Photolithographic</td>
<td>SMF</td>
<td>He-Ne [0.63]</td>
<td>-</td>
<td>[8]</td>
</tr>
<tr>
<td>Cylindrical lens</td>
<td>Multimode</td>
<td>GaAs</td>
<td>3</td>
<td>[9]</td>
</tr>
<tr>
<td>Hemispherical tipped lens</td>
<td>SMF</td>
<td>InGaAsP [1.29]</td>
<td>2.5-2.9</td>
<td>[10, 12, 13]</td>
</tr>
<tr>
<td>Hemispherical tapered end</td>
<td>SMF</td>
<td>InGaAsP [1.29]</td>
<td>&lt; 4.56</td>
<td>[11]</td>
</tr>
<tr>
<td>Confocal lenses</td>
<td>SMF</td>
<td>InGaAsP [1.29]</td>
<td>3.5</td>
<td>[12]</td>
</tr>
<tr>
<td>Confocal lenses</td>
<td>SMF</td>
<td>InGaAsP [1.29]</td>
<td>3</td>
<td>[13]</td>
</tr>
<tr>
<td>Etched conical lens</td>
<td>SMF</td>
<td>GaAlAs</td>
<td>4.56</td>
<td>[16]</td>
</tr>
<tr>
<td>Etched conical lens</td>
<td>SMF</td>
<td>InGaAsP [1.31]</td>
<td>2.84-3.0</td>
<td>[17]</td>
</tr>
<tr>
<td>Conical microlens</td>
<td>SMF</td>
<td>InGaAsP [1.31]</td>
<td>-</td>
<td>This work</td>
</tr>
</tbody>
</table>

The optical instrument design program starts with an introductory hands-on lens design which provides three basic skills: manual, design code, and design philosophy. Manual skills include first and third order calculations by hand, design code skills include prescription entry, optimization and design analysis, and design philosophy is about selecting a starting point and developing a plan of the design. The Advanced optical systems design and analysis beginning with modeling coordinate breaks, multi-configurations, systems analysis, tolerancing and athermalization. The last part in design analysis covers optomechanical systems design and bridges the gap between
the optical and the mechanical design environment. Several global optimization methods for lens design have been proposed[19-22].

The two lens design methods based on real-coded GAs, UNDX+MGG and UNDX+POSS[22] were very prominent. Both of them employ the UNDX[23] as a crossover operator that has shown good performance in optimizing multimodal functions with epistasis among parameters. The MGG[24] is a generation-alternation model for optimizing a single evolution function. On the other hand, the POSS[25] is for multiple evaluation functions.

4.4 Performance characteristics of microlens

It is well known that the first order theory is no more than a good approximation - an exact ray trace or even measurements performed on prototype system would certainly reveals inconsistencies with the corresponding paraxial description. Such departures from the idealized conditions of Gaussian optics are known as aberrations. There are two main types a) chromatic aberration and b) monochromatic aberrations. The later occurs even when the source is monochromatic one. There are monochromatic aberrations such as spherical aberration, astigmatism and coma that deteriorate the image, making it unclear.

All along that spherical surfaces in general would yield perfect imagery only in the paraxial region. Now we must determine the kind and exact of deviations those results simply from using those surfaces with finite apertures. By judicious manipulation of system parameters (shape, thickness, curvatures,
conic constant, paraxial distance, apertures, etc..) these aberrations can be indeed minimized. These minimized third order Seidel coefficients can be studied in terms of point spread function, spot diagram, MTF (Modulation Transfer Function), Encircled Energy and also in terms of Zernike coefficients.

4.5 Problem definition

Based on the literature survey, our problem focuses to improve the coupling efficiency of LD-SMF using conic microlens as couplers were calculated by applying ray tracing method. The systematic stages of approach to this problem as follows,

a) Modern conic lens design using Genetic Algorithm will be employed to design conic microlens in which care will be taken to minimize the chromatic aberrations.

b) Spot diagram, Point Spread Function(PSF), Optical Transfer Function(OTF), Encircled Energy(EE) were plotted using ZEMAX® software for conic constant values of 0.0, -0.4, -0.8, -1.2, -1.6, -2.0, -2.4 and -2.8 for incident angles of 0, 2, 4, 6, 8 and 10 degrees and its Seidel aberration coefficients will be compared with the theoretical results. The Zernike coefficients for third order Seidel aberrations will also compared with the previous findings.

c) Best performing lens with optimum conic constant value will be taken and employed in coupling scheme of LD-SMF, and its coupling efficiency will be theoretically determined for various axial distances. The theoretical and simulations results will be compared with the reported values.
4.6 References


