**Chapter Introduction**

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For the research of photonic waveguides it is normally in use to project lights from optical fibers to photonic waveguides (Fiber-to-Chip). In this case the source fiber is generally connected with the laser source because a laser is diffraction limited and highly concentrated. As the signal source optical fibers have usually a larger end face than that of waveguides and the direct coupling from fibers to waveguides cause a very low coupling efficiency. In order to handle this problem one consideration is to improve the propagating properties of the output beam from the fiber. For this reason tapered lensed fibers (TLF) \cite{TLF\_mode\_transforming,TLF\_analysis}, which are optical fibers with a tapered end and a lens on the end face, are used to replace normal fibers. In Fiber-to-Chip this new end face of fibers will focus rays emitted from fibers, so that more light power can be coupled into waveguides. Besides this thinking at the fiber side more activities can proceed at the middle propagating course and waveguide interfaces. In recent researches there are lots of discussions about the design of waveguide interfaces. Tapered interfaces \cite{design\_fabrication\_tapered\_waveguide}, grating interfaces \cite{fiber\_to\_chip\_grating\_waveguides} and other structures can greatly affect Fiber-to-Chip ability. In this work we discuss mainly about activities at the middle propagating course and waveguide interfaces.\\

As optimal designs for Fiber-to-Chip coupling, varieties of complex structures lead to great difficulties. Numerical methods are more suitable for solving Fiber-to-Chip problems. The purpose of this work, based on a given experimental setup about the Fiber-to-Chip problem, is to analyze different coupling configurations from TLF to photonic waveguide through simulations in CST MWS (CST Microwave Studio\textregistered) and Matlab programs, so that optimal Fiber-to-Chip interfaces can be found for achieving more effective coupling.\\

In this work the related basic knowledge for research and analysis are first introduced to clearify some terms in Fiber-to-Chip problem. Then the chapter \ref{chp:model} address information about the technical detail of the experimental objects and the modeling procedure. After then we simulate the unoptimized coupling arrangement and analyze the coupling behavior. In chapter \ref{chp:optim} we divide the development about the effective coupling between TLF and the waveguide into five sections. In the first section, we will talk about the effect of displacing the waveguide on the coupling efficiency. In the second section we will simulate the unoptimized coupling configuration in oil environment. Then in next three sections we consider designs of waveguide interfaces. Firstly, effects of material composing for waveguides are discussed. Then we provide two important structures of waveguide interfaces, tapered structure and lensed structure, for promoting the coupling ability respectively. At the end of this we conclude the above simulation results and give suggestions for optimizing the experimental setup.\\

由光纤投射光到光波导(fiber-to-chip)是研究集成光学中经常遇见的问题。在光学应用中，激光因为有限衍射，高汇聚性的特点入选为工作光源。而作为Fiber-to-chip问题的信号源光纤有着远大于光波导的终端截面。因此，这种直接耦合呈现出较大的能量损耗。为了解决这个问题，一方面可以通过改变光纤输出端特性的方法。梯形微透镜光纤（TLF）作为改善输出光源的手段引入到Fiber-to-chip耦合研究中用于替换普通传输光纤\cite{TLF\_mode\_transforming，TLF\_analysis}。在应用TLF的耦合中，光纤中透射出的光会被汇聚，使更多的光能量有机会耦合入光波导。除了以上在fiber侧改善输出光特性之外，还可以通过改变光在中间段的传输特性或者光波导接口的接收特性等其他手段来提升耦合效率。目前已经有很多对高效光波导接口的研究。梯形光波导接口\cite{design\_fabrication\_tapered\_waveguide}，阱条形波导接口\cite{fiber\_to\_chip\_grating\_waveguides}以及其他接口等都可能影响光波导的接收效率。\\

但是各种复杂多样的接口不再适合用解析的方法来，只能借助数值的方法来分析。本文在一给定的fiber-to-chip实验环境基础上，借助在数字仿真工具CSTMWS和Matlab程序建立不同的耦合模型，分析不同Fiber-to-chip耦合模型的特性及耦合效率，寻找最优的耦合配置，为实际物理实验提供参考结论。\\

本文在结构的开始先会介绍相关的基础知识，列举有关的关键概念。在接下来的章节首先是建立未优化之前的模型建立过程以及他的耦合性能分析。在优化模型的章节我们将内容分为5个小节。前两部分基于改变光在中间段的传输特性。首先考虑的是在xyz轴3个方向分别改变TLF和波导的相对位置，籍此观察对耦合效率的影响。另一个考虑就是将中间段的传输环境由空气变为液态油，然后观察仿真结果。接下来的3个小节则会考虑改变光波导的接口。首先考虑的是光波导的材料组合。通过仿真实验来寻找最适合给定发射源光波导配置。接下来的俩个章节则是改变光波导接口的几何结构。第一种结构是最常用的梯形结构端口，第二种则是透镜形接口。在比较以上5种模型之后可以给出对Fiber-to-chip问题的优化建议与期望。