# \chapter{Optimize}

## %introduction

This chapter aims to discuss the optimize methods so that the Fiber-to-Chip coupling efficiency improved. Four ideals are engaged in this chapter. One thought is to relocate the waveguide; another is to change the round condition of the coupling. The application of a taper interface at the beginning of the waveguide is involved in the next consideration. The last thought is to mount a lens at the waveguide interface.

## \section{Coupling by location shifting}

As a 3D model the waveguide can be shifted on transverse (Fig. \ref{fig:shift\_x\_axis} and Fig. \ref{fig:shift\_y\_axis}) or longitude (Fig. \ref{ fig:shift\_z\_axis }) directions.

\begin{figure}[!ht]

\centering

\includegraphics[width=0.6\textwidth]{bilder/ }

\caption{Displacing the waveguide along x-axis}

\label{fig:shift\_x\_axis}

\end{figure}

\begin{figure}[!ht]

\centering

\includegraphics[width=0.6\textwidth]{bilder/ }

\caption{Displacing the waveguide along y-axis}

\label{fig:shift\_y\_axis}

\end{figure}

\begin{figure}[!ht]

\centering

\includegraphics[width=0.6\textwidth]{bilder/ }

\caption{Displacing the waveguide along z-axis}

\label{fig:shift\_z\_axis}

\end{figure}

Shift the waveguide along X-Axis: Relocate the waveguide from $-0.3\mu$m to $0.3\mu$m and record their forward gain $S21$:

\begin{figure}[!ht]

\centering

\includegraphics[width=0.6\textwidth]{bilder/ }

\caption{Coupling efficiency due to the displacement the waveguide along x-axis}

\label{fig:efficiency\_shift\_x\_axis}

\end{figure}

Shift the waveguide along Y-Axis: Relocate the waveguide from $-0.3\mu$m to $0.3\mu$m and record their forward gain $S21$:

\begin{figure}[!ht]

\centering

\includegraphics[width=0.6\textwidth]{bilder/ }

\caption{Coupling efficiency due to the displacement the waveguide along y-axis}

\label{fig:efficiency\_shift\_y\_axis}

\end{figure}

Shift the waveguide along Z-Axis: Relocate the waveguide from $-0.5\mu$m to $0.5\mu$m and record their forward gain $S21$:

\begin{figure}[!ht]

\centering

\includegraphics[width=0.6\textwidth]{bilder/ }

\caption{Coupling efficiency due to the displacement the waveguide along z-axis}

\label{fig:efficiency\_shift\_z\_axis}

\end{figure}

And all detail are listed in Tab.\quad\ref{tab:shift\_result}.

\begin{Table}

\caption{shifting the waveguide along X-Axis}

\begin{Tabular}{cccc}

\hline

Shift|direction& X-Asis & Y-Axis & Z-Axis \\

\hline

$-0.3\mu$m &

$-0.2\mu$m&

$-0.1\mu$m&

$0\mu$m&

$0.1\mu$m&

$0.2\mu$m&

$0.3\mu$m\\

\hline

\end{tabular}

\label{tab:shift\_result}

\end{table}

Load all shifting data and draw their curves in Fig. \ref{fig:shift\_curve}, which present us their coupling efficiency behavior. It is obvious that the coupling performance falls very quickly for vertical or horizontal shifting, while it decline slowly in the observing range.

\begin{figure}[!ht]

\centering

\includegraphics[width=0.6\textwidth]{bilder/shift\_curve}

\caption{Coupling efficiency due to the displacement of the wavguide.}

\label{fig: shift\_curve}

\end{figure}

## \section{oil Environment}

## \section{Tapered waveguide}

Tapered waveguide is

## \section{Lensed waveguide}

In many articles it has been well discussed about the coupling between laser source and lensed fiber\ref{microlensese\_to\_fiber\_coupling}\ref{integrated\_coupling \_between\_LD\_SMF}. Authors of \ref{microlensese\_to\_fiber\_coupling} proved that the coupling efficiency of their design reached maximum about $56%$. \ref{integrated\_coupling \_between\_LD\_SMF} has also shown a minimum coupling loss less than $2$dB with application of a microlens. In compare with our previous works, our design could gain higher performance by the use of a microlens at the interface of the waveguide. For the fabrication it may be not easy to mount a microlens on a stript rib waveguide. But in \ref{lens\_end\_manufacture} the process sequence for fabricating the lens on the fiber end brings us the possibility to create a lens on a symmetric buried waveguide. In this section the coupling efficiency between TLF and the symmetric buried and lensed waveguide (or lensed waveguide) will be discussed. In this section the coupling efficiency between TLF and basic symmetric waveguide will at first be calculated as the reference for further discussing. Then we will engage the lensed waveguide and the effect of changing the lens geometric parameters of the waveguide.

### \subsection{Coupling between TLF and basic symmetric waveguide}

In agreement with the waveguide in the experiment, the symmetric waveguide model likes Fig. \ref{fig:sym\_waveguide} is created with the same corresponding parameters. The waveguide in this section contains the identical dimensions ($w$ and $h$) and refractive indexes (n$\_{1}$ and n$\_{2}$) with the original waveguide.

\begin{figure}[!ht]

\centering

\includegraphics[width=0.6\textwidth]{bilder/symmetric\_waveguide

\caption{Schema of a symmetric waveguide}

\label{fig:sym\_waveguide}

\end{figure}

Fig. \ref{} shows the coupling efficiency between TLF and the basic symmetric waveguide due to the frequencies. The coupling efficiency at the working frequency $282$THZ reaches about $51.3%$, which is relative better than stripped rib waveguide. With this reference value further

### \subsection{effect of lens radium}