Packaging of Tapered Waveguides with MT Connectors to Cost Effectively Facilitate Connection of Single-mode and Multi-mode Optical Networks

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ABSTRACT

With the rapid expansion of short haul data communication (multi-mode optical) networks and the conversion of long haul telecommunication (single-mode optical) networks from voice to IP based data protocols, an optical technique to combine these two networks as well as other mode mismatched networks and components must be developed. Since the interface of these networks will be with-in centralized routers/hub/switching stations which involves multiple channels/optical fibers, a low loss cost effective solution is required for a multi-channel physical fiber connection between the networks. Currently one standard multi-channel fiber connector, the (MT) mechanically transferable, is widely used on both types of networks and fortunately shares with one exception, the same physical fiber ferrule form factors that could facilitate the physical interface between these networks. To compensate for the one exception (mode mismatched dissimilar fiber core diameters) a tapered waveguide that is physically matched to each network fiber core type has been package to facilitate low loss coupling with MT connectors. A technical description follows for packaging tapered waveguides supplied from Radiant Research Inc. into a form suitable for connection between a single and multi-mode MT connector. This form will be referred as a MT stand-off.

Keywords: taper waveguide, coupling, MT ferrule/connector

1. INTRODUCTION

Radiant Research Inc. over the last four years has evaluated and produced polymer tapered waveguides compression molded on top of a silicon wafer [1]. This compression molded waveguide, shown in figure 1, has a square form factor, which is tapered on the three sides above the flat substrate. Radiant's evaluation included detail mode propagation analyses, that show how the tapered waveguide is designed as an adiabatic device, in which the optical power is predominantly guided by the fundamental mode in order to improve coupling efficiency of mode mismatched optoelectronic devices.

One potential commercial application of tapered waveguides would be to provide an optical technique to combine short haul data communication (multi-mode) and the long haul telecommunication (single-mode) optical networks. Since, the standard multi-channel fiber (MT) mechanically transferable connector is widely used on both types of these networks, a multi-channel tapered waveguide in a MT form factor is being developed. . This MT compatible multi-channel tapered waveguide will be referred as a MT stand-off. The stand-off is physically matched to each network fiber core type, to facilitate low loss coupling between single mode and multi-mode MT connectors

This MT stand-off can also facilitate coupling between other mode mismatched networks and components like the coupling of VCSELs to various standard fiber sizes. A VCSEL stand-off using these tapered waveguides can replace a similar device [2] in a more cost effective mode matching manner.

New Century Consulting was contracted by Radiant Research to design a product package for this taper waveguide, specify this design for procurement, and then aid in this product procurement.

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Part of the SPIE Conference on Optoelectronic Interconnects VI
San Jose, California • January 1999
SPIE Vol. 3632 • 0277-786X/99/$10.00

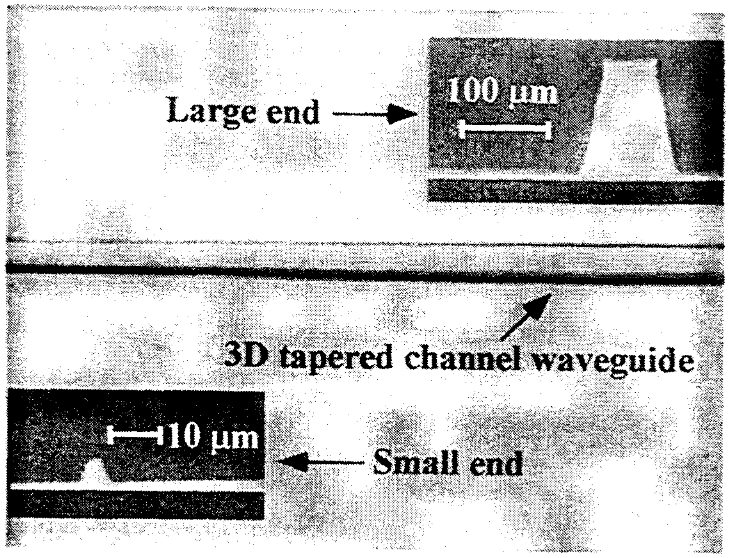

Figure 1. Photo picture of a small section of the molded 3D linear tapered waveguide fabricated by Radiant Research. The cross sections of the two ends are also shown in this figure.

2. DESIGN APPROACH

Currently three multi-channel MT ferrules (2 wide, 12 wide, and 16 wide) are commercially available for use in various MT connectors and on VCSEL transceivers. All of these ferrules are very similar in that they are fabricated to function with both single mode and multi-mode fiber and have multiple channels on 250micron centers for which the ferrule size varies to accommodate the three different width standards. We decided to tool a 2 channel stand-off, since demonstrating the tapered waveguide on the lowest tooling cost 2 channel ferrule, should be extendable to the other wider ferrules; and since this mini MT ferrule has been selected as the MTRJ connector for use on Gigabit VCSEL Ethernet transmitters.

Our initial MT stand-off design approach was to assemble Radiant supplied tapered waveguides into a stand-off. However, recognizing that the most producible (highest risk) design approach would be to mold the tapered waveguides into a MT ferrule form factor, we decided to concentrate our efforts on the molding approach. Since, new mold tooling would be required, we decided to switch from the reference (1) square taper form factor to a cylinder waveguide to improve the adiabatic coupling and MT alignment. Based on University of Texas supplied analysis of this new cylindrical waveguide, the MT/stand-off was specified per Figure 2 to facilitate alignment tolerances associated with MT ferrules.

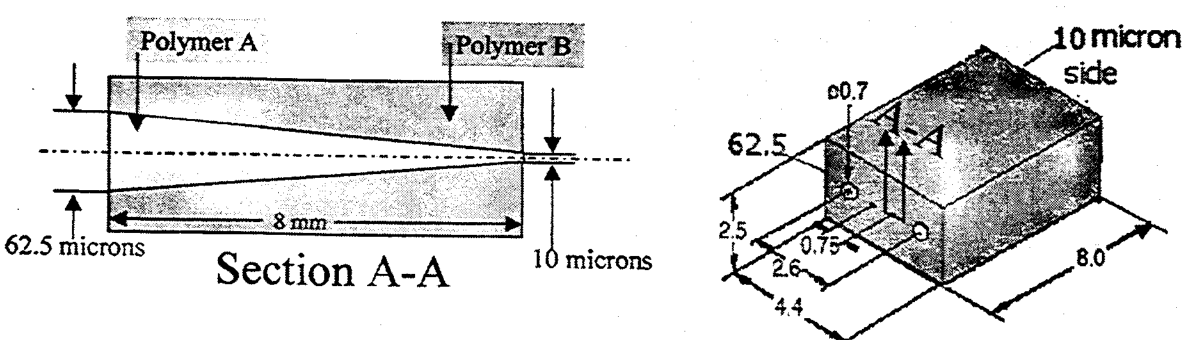

Figure 2 specifies the MT stand-off design. Polymer A has a refractive index of 1.6 or greater and Polymer B has a refractive index of 1.5 or less.

The initial stand-off coupling technique relies on a clip to force two MT ferrules into opposite end contacted against the stand-off per figure 3. This clip is a lengthened version of what is used by USCONEC, Hickory N.C., for MT ferrule to ferrule coupling. Later stand-off versions will be integrated with MTRJ connector snap on/off couplers as depicted in figure 3.

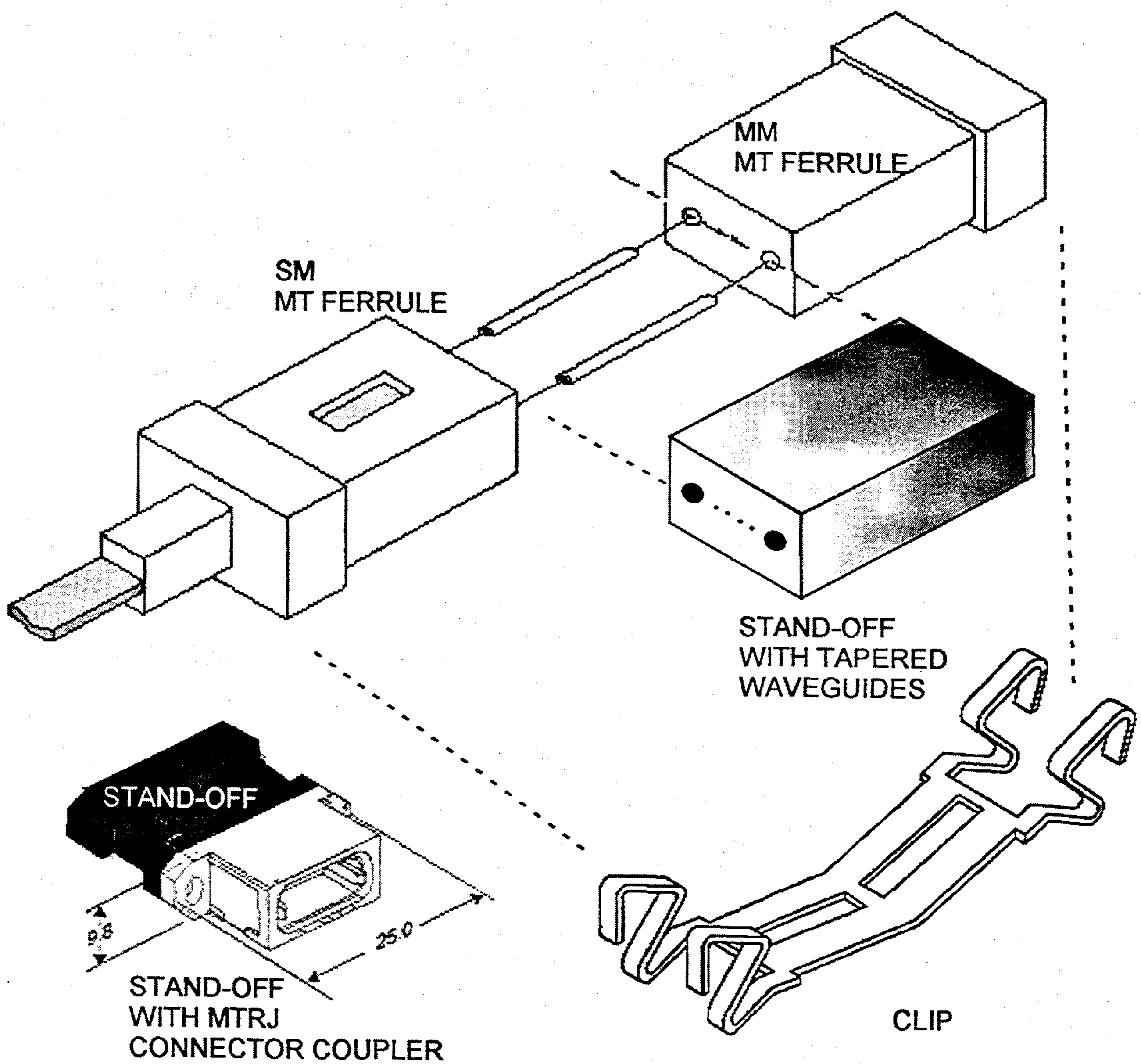

Figure 3 shows the initial MT stand-off coupling approach using a clip to butt couple a single mode and multi-mode MT ferrule to the MT stand-off. Later stand-off versions as shown can be tooled with MTRJ connectors on either end of the stand-off so single mode and multi-mode MTRJ connectors can be coupled.

A low level back-up assembly approach was also designed to assemble the taper waveguides into a MT ferrule using waveguide position plates per figure 4. The two options shown in figure 4 could be fabricated from either a stretched core cladding waveguide or a core material only, for which would require cladding attachment during assembly. The alignment plates would center position the taper in the MT ferrule, which after waveguide potting would then be polished back to desired diameter depending on the size of fibers this stand-off is coupling. A similar approach for ST connector devices was also designed.

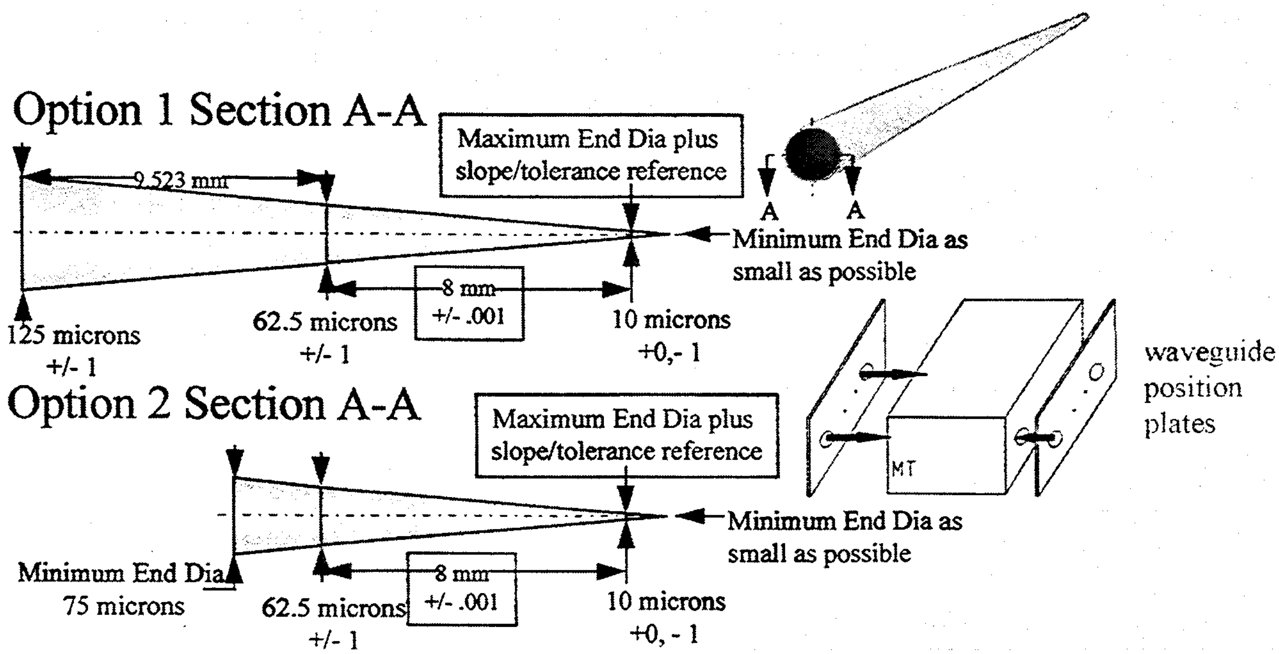

Figure 4. Depicts assembly of the taper waveguides into a MT ferrule using waveguide position plates on either end of a MT ferrule to center and position the taper waveguides.

3. PROCUREMENT STATUS/ FUTURE ACTIONS

An optical device molding approach was selected based on responses to the figure 2 specifications. Fabrication processes are under development for mass production. At the same time, the waveguide assembly approach is also being investigated. In this approach laser machined alignment aids and tapered fiber waveguides have been successfully fabricated. To date procurement of the waveguides, however, have resulted in devices that have greater slopes, short tapers, than is required to obtain good adiabatic coupling. This assembly approach has provided the techniques to develop tooling for a new MT stand-off mold, which will benefit our molding approach.

4. CONCLUSIONS

A taper waveguide package design, mini MT-stand-off, has been selected that provides an optical technique to combine short haul data communication (multi-mode) and the long haul telecommunication (single-mode) optical networks and components. The mini MT-stand-off design specifics have been documented and released to the supplier community for which a molding process is under development.

5. ACKNOWLEDGMENTS

This research is sponsored by the BMDO, AFRL, AFOSR, and 3M.

5. REFERENCES

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