韓國精密工學會 2004 年度 秋季學術大會論文集

자동 광축 정렬시스템을 이용한 초소형 광통신용 마이크로 OADM 제작 및 Aging effect

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Fabrication and Aging effect of Micro OADM using Automatic Alignment System

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ABSTRACT

Optical add/drop multiplexers (OADMs), one of the new network elements, will play a key role enabling greater connectivity and flexibility in the dense wavelength-division multiplexing (DWDM) networks. The importance of OADMs is that they allow the optical network to be local transmitting/extraction on a wavelength-by-wavelength basis to optimize traffic, efficient network utilization, network growth, and to enhance network flexibility. Also, the automatic assembly system of micro optical filters and fibers is a key technology in the development of optical modules with high functionality. Recently, one of remarkable tends in the development of optical communication industry is the miniaturization and integration of products. In this research, we have developed a system capable of automatic alignment of a film filter and a lensed fiber in order to improve the speed and losses in the optical fiber to filter alignment of optical modules. Using the developed automatic alignment system and silicon optical benches, we have fabricated the micro OADM and measured the insertion loss and aging effect.

Key Words : Micro OADM (Optical Add/Drop Multiplexer), Film Filter, Lensed Fiber, TEC(Thermal Expanded Core) Fiber, Packaging, Insertion Loss, Aging Effect

1. Introduction

With the deployment of dense wavelength division multiplexing (DWDM), the efficient use of fiber bandwidth becomes imperative. Optical add/drop multiplexers (OADMs), with the ability to selectively drop and /or add individual channel or subset of wavelength from the transmission system without full opto-electronic regeneration of all wavelengths makes it possible to manipulate the traffic on the wavelength basis at the optical layer. (1-3) Optical filter is indispensable to control the desired optical information since it carries out various functions, e.g., to improve communication's efficiency through transmission, reflection and division of the desired wavelength, and energy control. (4-6) WDM (Wavelength Division Multiplexing), one of methods transmitting a great deal of information by using optical filter, is becoming a subject of research because of the extreme increase of transmission quantity and the possibility of development into optical network. Especially, OADM has been becoming a key part as point-to-point WDM was shifted into add-drop WDM. The optical filter, which makes wavelengths transmitted selectively, is a component that spends much time during operating since the method of measurement and evaluation is not effective. In packaging process of optical fibers and filters, the yield of products drops dramatically because the performance of the modules is measured after the packaging process. Moreover, most productions of optical module using optical filters are presently depending on handwork, and only several companies are promoting semi-auto lines combined with manual and auto types. The cost is a critical problem in designing and implementing of OADM, especially the recent business downturn puts more significant pressure on substantial cost reduction while improving performance simultaneously. [3] Therefore, the development of production automation system for optical modules is the most essential technology to guarantee price competitiveness and uniformity of the optical modules. [7]

In this paper, we have fabricated and designed the micro OADM using a optical bench and a system of the performance evaluation of optical filters that can measure and evaluate film filters of about 30 μm-thick as well as general optical filters (CWDM, DWDM) for optical communication. We have measured the aging effect of the micro OADM. Also, we have developed a program of performance evaluation for automatic alignment of optical axes and optical filters. The system and program are important technologies for measurement and evaluation that are a basis to construct a connection/assembly system.

2. Experimental

2.1 Construction of connecting/assembly system of OADM

We have designed and fabricated an assembly and evaluation system for thin film filters as well as conventional filters for optical communication as shown in Fig. 1. After minimizing the insertion loss of input end and the receiver of laser source, micro alignment is carried out to maximize optical qualities by moving regular or thin film optical filters. The filters are measured and evaluated in the optimal conditions. The system is composed of driving, sensor, and control modules. And it has a possibility of realizing the system having the connecting/assembly technology for the production system of optical modules with high functionality in the future.

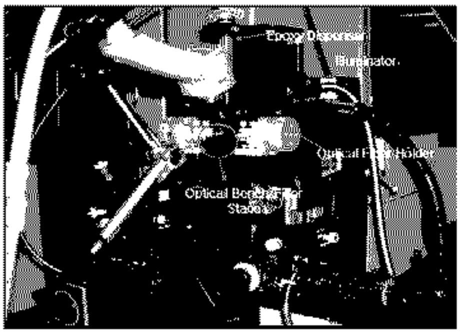

Fig. 1 Automatic optical fiber/filter alignment system.

2.2 Optical bench fabrication

In the development of optical communication, electronics, and bio industries, which are currently improving, the most marked trend is the miniaturization and integration of various products.

In this research, we have fabricated a bench that fixes both film filters and lensed fibers by using semi-conductor processes to develop OADM. The reason we adopted the semi-conductor processes is because the micro-fabrication is hard to fix film filters and lensed fibers through the conventional mechanical manufacturing. Figure 2 is the SEM photograph of a fabricated bench. We have designed 8 models and the important dimensions are the pitch and depth of insertion part of a film filter. The pitch of filter insertion part is 40 μm and 50 μm, and its depth is 350 μm. The insertion depth of lensed fiber is 150 μm. The total sizes of optical bench are 2300 μm x 3300 μm, 1500 μm x 2300 μm, and 2300 μm x 1500 μm, respectively, and the supporting areas of insertion part of a film filter are designed to be rectangle and circle.

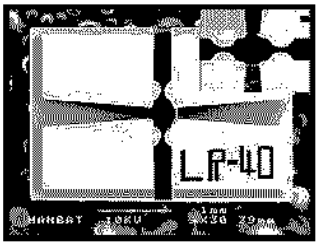

Fig. 2 SEM photograph of optical bench fabricated by using Si.

2.3 Connection/assembly processes of OADM

The packaging process consists of three processes. The first packaging process is to connect the bench and film filter, and the second and third processes are to join two lensed fibers. The packaging system is composed of UV curing system, dispenser, and optical table.

On the first, second, and third packaging, the nozzle stub of dispenser dispenses a little epoxy on both film filter and lensed fiber that the insertion is finished. And then the packaging is performed by irradiating UV light for a given period and rapidly curing the epoxy.

This optimum process is developed and applied by controlling the intensity and irradiating time of UV light that make the adhesive shift minimized when curing the epoxy. The key process in packaging is the optical axes alignment of the lensed fiber connected on the second and third packaging. At that time, by using CCD camera, the lensed fiber is inserted in the fiber insertion hole of bench. And by using the high precision optical axis alignment program, optical alignment is carried out to be minimum insertion loss. When the axis alignment is finished, the performance is evaluated through the performance evaluation program.

3. Results and discussions

3.1 Performance evaluation of OADM

In this research, by inserting the film filter and lensed fiber on the bench before the packaging of OADM optical modules, we have performed an experiment of deciding the position that the insertion loss is a minimum. Moreover, we could obtain the fundamental data needing for the packaging of optical devices using the epoxy in the future, due to measuring the insertion values on the optimum positions. Figure 3 is the picture of aligning each part on the bench before dispensing the epoxy, and then a penetration filter of center wavelength of 1500 nm was used as the film filter. Figure 4 shows the fabrication process of a micro OADM using the automatic alignment system.

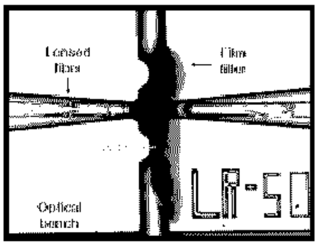

Fig. 3 Alignment before packaging of the micro OADM.

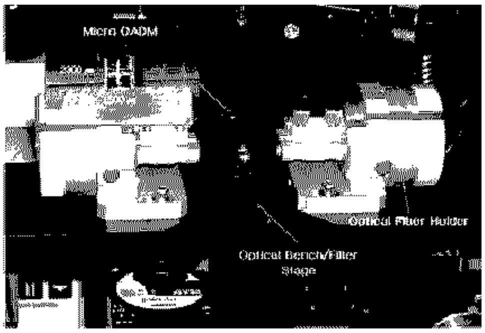

Fig. 4 Fabrication process of the micro OADM using the automatic alignment system.

As a result measured by the performance evaluation program after deciding the position of lensed fiber, Fig. 5 shows that the light is precisely penetrated in center wavelength of 1500 nm and is reflected in the below wavelength of 1500 nm. The transmission insertion loss (TIL) was measured with 0.294 dB that is less than 0.3 dB of a standard value of measurement evaluation of optical modules. Therefore, we can find out the position that the insertion loss is the smallest through the experiment of deciding position. We have carried out the packaging after finishing the automatic optical axis alignment that the insertion loss value is a minimum.

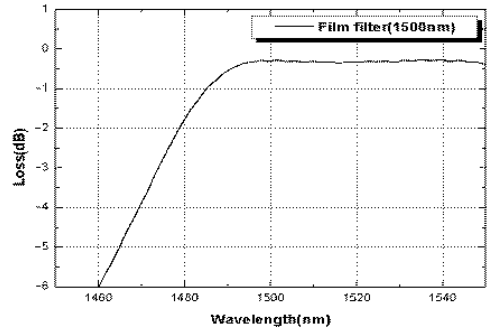

Fig. 5 Performance and evaluation after optical axis alignment of the micro OADM.

Figure 6 is a result that measured the insertion loss values after packaging OADM by using the optical axis automatic alignment system. The insertion loss before packaging is 1.2 dB. The insertion loss after the packaging is about 1.5 dB and its result would be because of the micro shift of optical alignment and the defect of film and filter by the epoxy when packaging. In the work, we could obtain a satisfied result by succeeding to package OADM optical modules on the order of micros by using the automatic optical axis alignment system. We plan to carry out the experiment that minimizes the micro shift of fibers of optical axis alignment and the defect of film and filter by the epoxy.

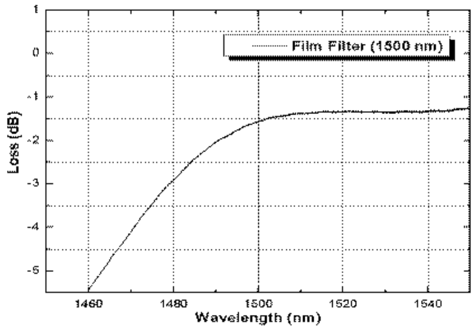

Fig. 6 Performance and evaluation after packaging of the micro OADM.

3.2 Aging effect of micro OADM

After finishing all three packages of OADM (after completing the fabrication of OADM), we have measured insertion losses according to the before and after of epoxy curing and aging time. Figure 7 shows insertion loss of the before and after of epoxy curing and after aging. When comparing after epoxy curing with before epoxy curing, the insertion loss of after epoxy curing becomes bigger. But the value was almost similar with the insertion loss of before curing after aging. As shown in Fig. 8, we could confirm that as time passes, the micro shift of fiber by epoxy becomes more stable and thus the insertion loss becomes better.

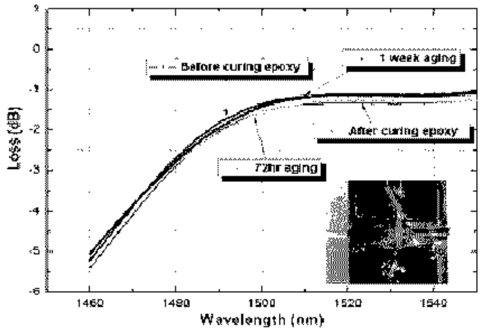

Fig. 7 Aging effect of the micro OADM.

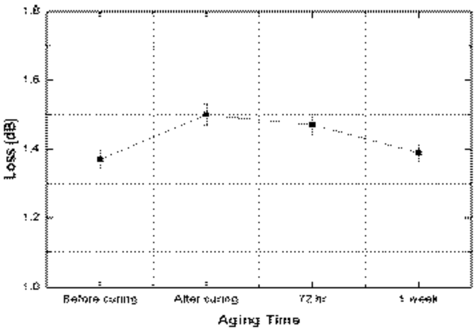

Fig. 8 Variation of insertion loss of the micro OADM according to aging time.

4. Conclusions

In order to fabricate the optical module connection/assembly system, we have developed the system capable of connection/assembly of film filters of about 30 ㎛ in thickness and lensed fibers. Also we have carried out the experiment of position decision that the insertion loss is the smallest by inserting the film filter and lensed fiber on the bench before packaging the OADM optical module. As a result, the insertion loss is 0.294 dB that is measured below 0.3 dB that is a standard of measurement evaluation of optical module. So we could obtain the position decision technology that is the most important for module packaging, and succeed to fabricate the OADM optical module by using the automatic optical axis alignment system. The insertion loss of the OADM optical module on the order of micros that was fabricated in this work was about 1.5 dB. And then, we have measured the aging effect of the micro OADM according to the aging time. We could confirm that as time passes, the micro shift of fiber by epoxy becomes more stable and thus the insertion loss becomes better. It is considered with an excellent product that can play an important role in the communication industry. And based on the automatic optical module packaging technology, it is expected to achieve communication parts with high performance, low price, and miniaturization by constructing the automatic assembly system capable of fabricating and evaluating optical communication parts with high functionality. In addition, the technology can contribute to the fundamental technology and commercialization technology in the optical industry, such as photoelectric parts, complex passive optical parts, photoelectric integrated circuits, and optical systems.

Acknowledgments

This work has been supported by the next generation novel technology development program of Ministry of Commerce, Industry and Energy (MOCIE) under project title of "Development of Micro Optical and Thermofluidic Devices with High Functionality."

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