Extended Abstracts of the 2001 International Conference on Solid State Devices and Materials, Tokyo, 2001, pp. 612–613

E-9-2

Reliability of Tellurite Fiber Module for Fiber Amplifier Applications

H. Ono, Y. Nishida, K. Shikano, A. Mori, K. Hoshino*, T. Kanamori*, Y. Ohishi*, and M. Shimizu

NTT Photonics Laboratories, Tokai, Naka, Ibaraki 319-1193, Japan
Phone: +81-29-287-7535, Fax: +81-29-287-7193, E-mail: hono@iba.iecl.ntt.co.jp
*NTT Electronics Corporation, Tokai, Naka, Ibaraki 319-1106, Japan

1 Introduction

An erbium-doped tellurite fiber is an attractive device because it can expand the amplification wavelength range of an L-band erbium-doped fiber amplifier (EDFA) .beyond 1615 nm as well as achieve a seamless amplification band of over 70 nm in the 1.5 μm transmission band [1,2]. A tellurite fiber must be spliced to a silica fiber for practical use because passive optical components have silica fiber leads. Therefore we have developed a tellurite fiber module with sealed package and silica fiber leads for amplifier use, that is similar to our previously reported fluoride fiber module [3]. One of the most important properties of a fiber module as regards its commercial use is its reliability. However, no reliability tests have yet been reported for tellurite fiber modules. This paper describes the reliability of our tellurite fiber module by means of tests largely based on Telcordia GR-1221-CORE [4], and under a practical operating condition.

2 Tellurite Fiber Module

We developed a tellurite fiber module similar to the fluoride fiber module, the latter having good reliability in terms of the Bellcore Technical Advisory TA-NWT-001221 [3]. The tellurite fiber module consists of a tellurite fiber, a fiber bobbin, a V-groove connection [5], high-NA silica fiber, standard silica fiber, and an aluminum case.

The tellurite fiber had a Δn of 1.5 %, a core diameter of 3 μm, a cutoff wavelength of 1.4 μm, and an Er concentration of 1000 ppm. The fiber was coiled around a bobbin 75 mm in diameter and 5 mm high and was 5 m long. We used the V-groove connection to splice the tellirite fiber and silica fibers mechanically. We connected the tellurite fiber to high-NA silica fibers whose mode field diameters were matched to that of the tellurite fiber by using UV curable adhesive. We then fusion spliced the high-NA silica fibers to standard silica fibers. We used tilt-cut V-grooves and the thermally diffused expanded core (TEC) technique for the tellurite fiber to high-NA silica fiber connection and the high-NA fiber to standard silica fiber connection, respectively. These connection techniques reduced the splicing loss and reflection to less than 0.3 dB and less than −60 dB, respectively.

3 Reliability Test Procedure

We tested the reliability of our tellurite fiber modules largely in accordance with Telcordia GR-1221-CORE and their long term operation with high pump power. This advisory is used for ensuring the reliability of passive optical components. Since no appropriate reliability standard has been established for tellurite fiber modules, we followed the test described in GR-1221-CORE based on the fact that the tellurite fiber module itself is a passive optical component without pump power. We recorded the loss change of the samples with online monitoring during cycling moisture resistance and temperature cycling tests. We selected a wavelength of 1200 or 1300 nm for the loss measurement to avoid erbium ion absorption loss. We collected the loss values in damp heat, low-temperature storage, heat shock and vibration tests by using the cutback method at room temperature in the interim downtime and after the tests had been completed. We considered a sample to have failed if there was a loss change of more than ±0.2 dB.

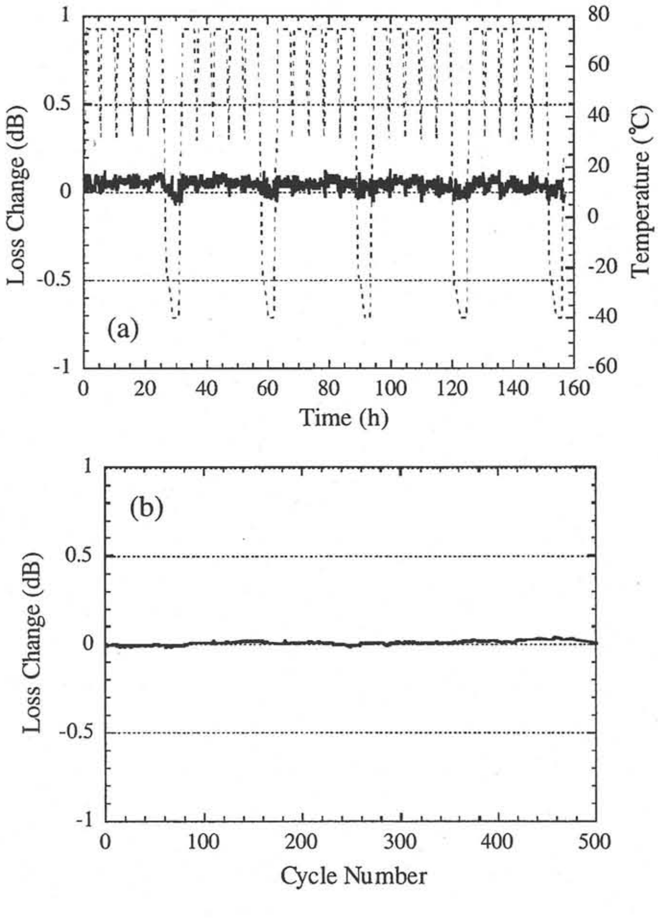

Figure 1 (a) Loss change in cycling moisture resistance test. The solid line and dashed lines show the loss change and temperature profile, respectively. (b) Loss change in temperature cycling test.

We also tested the module under operating conditions with a high pump power of 500 mW. We compared signal gain spectra before and after pumping.

4 Results

Figure 1 (a) and (b) show examples of the loss change in a cycling moisture resistance test against elapsed time and in a temperature cycling test against cycling time, respectively. The temperature was changed from −40 to 75 ˚C (shown by the dashed line in Fig. 1). and the humidity was 90 %RH at 75 ˚C in the cycling moisture resistance test and from −40 to 75 ˚C in the temperature cycling test. The temperature cycling test was based on Bellcore Technical Advisory TA-NWT-001221 [6]. The loss change was ±0.2 dB during the tests shown in Fig. 1 (a) and (b), and all the 11 tested samples exhibited a similar loss change of ±0.2 dB.

Figure 2 shows an example of the loss change in the damp heat test against elapsed time. The temperature was 75 ˚C and the humidity was 90 %RH. The figure shows that the loss change was less than ±0.2 dB. All 11 samples exhibited a similar 2000 h of trouble-free storage with a loss change of less than ±0.2 dB. These samples also exhibited 2000 h of trouble-free storage with a loss change of less than ±0.2 dB in a low-temperature storage test (−40 ˚C).

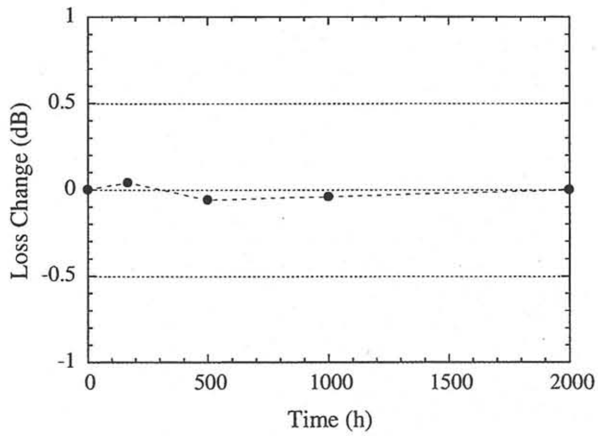

Figure 2 Loss change in damp heat test.

The results of our reliability tests largely based on Telcordia GR-1221-CORE are summarized in Table 1. These results show that our tellurite fiber module can withstand harsh environmental conditions and has sufficient mechanical strength.

Figure 3 shows small signal gain spectra before and after 250 hours of continuous amplification. The condition of the continuous amplification was that the pump wavelength and power were 1480 nm and 500 mW, respectively, and the signal wavelength and power were 1560 nm and +3.8 dBm, respectively. We observed no degradation in the small signal gain spectrum after high power pumping. There was also no degradation in the noise figure. This indicates that our tellurite fiber module has sufficient reliability under practical operating condition.

Table 1 Reliability Test Results

Test	Conditions	Samples	Trouble
Cycling moisture resist.	−40 °C to 75 °C / 90 %RH, 5 complete cycles	11	0
Temp. cycling	−40 °C to 75 °C, 500 cycles	11	0
Damp heat	75 °C / 90 %RH, 2000 h	11	0
Low temp. storage	−40 °C, 2000 h	11	0
Heat shock	−40 °C to 75 °C	11	0
Vibration	10 to 2000 Hz, 3 directions	11	0

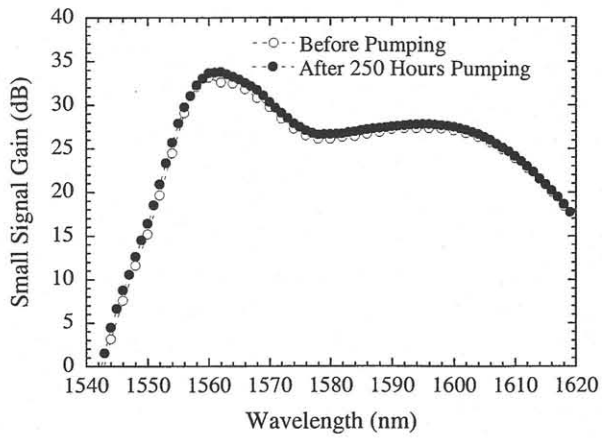

Figure 3 Small signal gain spectra before and after 500 mW pumping.

5 Conclusion

We performed reliability tests on our tellurite fiber module largely based on the Telcordia GR-1221-CORE and under practical operation conditions. Trouble-free results for cycling, storage and mechanical tests and the absence of degradation in the amplification characteristics after high power pumping revealed that our tellurite fiber module has long-term stability under practical environmental and operating conditions.

Acknowledgements

The authors thank K. Nakagawa, K. Kobayashi, T. Sakamoto, M. Yamada, and Y. Hiraki for useful discussions, and K. Oikawa and K. Kato for fiber module preparation. The authors are also very grateful to T. Maruno for continuous encouragement.

References

[1] A. Mori et al., *Electron. Lett.*, vol. 36. p. 621, 1998.
[2] M. Yamada et al., *Electron. Lett.*, vol. 36. p. 1244, 1998.
[3] Y. Nishida et al., *IEEE Photon. Technol. Lett*, vol. 11, p. 1596, 1999.
[4] Telcordia, GR-1221-CORE, Issue 2, 1999.
[5] M. Yamada et al., *IEEE Photon. Technol. Lett*, vol. 4, p. 906, 1991.
[6] Bellcore Technical Advisory, TA-NWT-001221, 1991.