Tuesday, July 17, 2018

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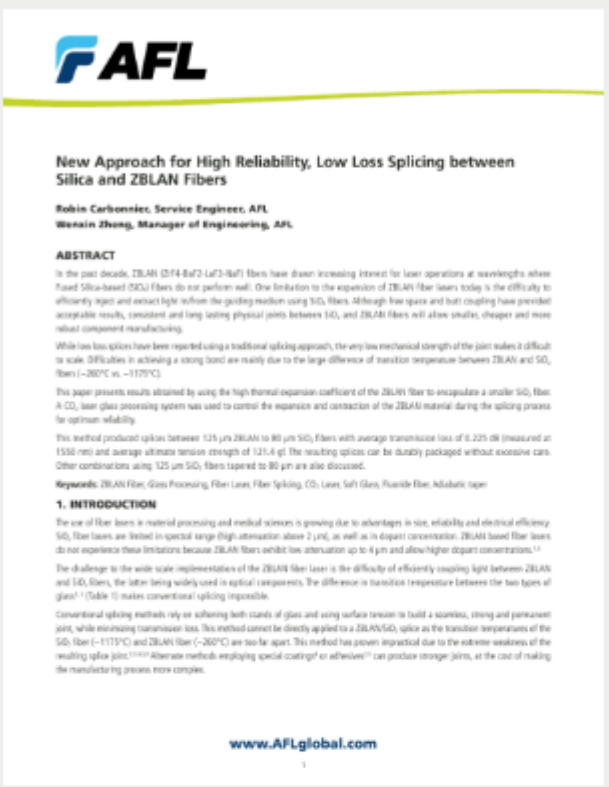
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New Approach for High Reliability, Low Loss Splicing between Silica and ZBLAN Fibers

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ABSTRACT

In the past decade, ZBLAN (ZrF4-BaF2-LaF3-NaF) fibers have drawn increasing interest for laser operations at wavelengths where Fused Silica-based (SiO_2) fibers do not perform well. One limitation to the expansion of ZBLAN fiber lasers today is the difficulty to efficiently inject and extract light in/from the guiding medium using SiO_2 fibers. Although free space and butt coupling have provided acceptable results, consistent and long lasting physical joints between SiO_2 and ZBLAN fibers will allow smaller, cheaper and more robust component manufacturing.

While low loss splices have been reported using a traditional splicing approach, the very low mechanical strength of the joint makes it difficult to scale. Difficulties in achieving a strong bond are mainly due to the large difference of transition temperature between ZBLAN and SiO_2 fibers (~260°C vs. ~1175°C).

This paper presents results obtained by using the high thermal expansion coefficient of the ZBLAN fiber to encapsulate a smaller SiO_2 fiber. A CO_2 laser glass processing system was used to control the expansion and contraction of the ZBLAN material during the splicing process for optimum reliability.

This method produced splices between 125 µm ZBLAN to 80 µm SiO_2 fibers with average transmission loss of 0.225 dB (measured at 1550 nm) and average ultimate tension strength of 121.4 gf. The resulting splices can be durably packaged without excessive care. Other combinations using 125 µm SiO_2 fibers tapered to 80 µm are also discussed.

Keywords: ZBLAN Fiber, Glass Processing, Fiber Laser, Fiber Splicing, CO_2 Laser, Soft Glass, Fluoride Fiber, Adiabatic taper

1. INTRODUCTION

The use of fiber lasers in material processing and medical sciences is growing due to advantages in size, reliability and electrical efficiency. SiO_2 fiber lasers are limited in spectral range (high attenuation above 2 µm), as well as in dopant concentration. ZBLAN based fiber lasers do not experience these limitations because ZBLAN fibers exhibit low attenuation up to 4 µm and allow higher dopant concentrations.[1,2]

The challenge to the wide scale implementation of the ZBLAN fiber laser is the difficulty of efficiently coupling light between ZBLAN and SiO_2 fibers, the latter being widely used in optical components. The difference in transition temperature between the two types of glass[3,4] (Table 1) makes conventional splicing impossible.

Conventional splicing methods rely on softening both stands of glass and using surface tension to build a seamless, strong and permanent joint, while minimizing transmission loss. This method cannot be directly applied to a ZBLAN/SiO_2 splice as the transition temperatures of the SiO_2 fiber (~1175°C) and ZBLAN fiber (~260°C) are too far apart. This method has proven impractical due to the extreme weakness of the resulting splice joint.[5,6,7,8] Alternate methods employing special coatings[9] or adhesives[10] can produce stronger joints, at the cost of making the manufacturing process more complex.

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