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Description

Technical Field

This invention relates to methods for welding relatively small parts and, more particularly, to methods for welding an outer sleeve to an optical fiber ferrule.

Background of the Invention

Recent advances in lasers, optical components and optical fibers for transmitting information in the form of lightwaves have led to proposals for generalized lightwave communications systems. The proposed use of lightwave communication as a general alternative to telephone communications presupposes an ability to make small optical components in great volume and with great precision. One basic component for such systems would be the optical coupler for transferring information to an optical fiber and removing information from the optical fiber, as is described, for example, in the U.S. patent of DiDomenico et al. No. 4,165,496, granted August 21, 1979, and assigned to Bell Telephone Laboratories, Inc. The assembly of such an optical coupler requires proper alignment and positioning of two abutting optical fibers.

Positioning of a small diameter optical fiber with respect to an optical coupler is now typically done by mounting the optical fiber in a ferrule. The ferrule is snugly fitted within a sleeve which is moved axially to a proper position and then the ferrule is bonded to the outer sleeve. Thereafter, the sleeve is fixed to the coupler and is rotated to give the optical fiber a proper angular alignment with respect to the coupler.

Optical fiber is normally bonded within the ferrule by an epoxy, which has been found to be satisfactory. It is, however, difficult to bond the ferrule to the outer sleeve after the required axial adjustment has been made. Laser welding is the most practical method for such bonding, but it poses problems because it is not practical to use it to fuse through the entire thickness of the outer sleeve. Such welding would require undesirably high laser power, and the concomitant heat would tend to distort the elements. Thus, attempts have been made to laser bond at the interface between the sleeve and the ferrule, which is difficult because of the accurate placement of the laser beam that is required. There is, therefore, a need for a method for welding the relatively small sleeve to the optical fiber ferrule in a manner that is readily amenable to mass production.

EP-A-286 319 discloses a method as defined in the preamble of claim 1.

In accordance with the present invention there is provided a method as defined in claim 1.

In accordance with the invention, laser welding of an outer sleeve to an inner fiber ferrule is greatly expedited by, first, machining a thinned region in the outer diameter of the sleeve. After the ferrule has been inserted into the sleeve, the thinned region permits the laser to fuse through the sleeve and melt part of the ferrule, as is required for laser welding of the ferrule to the sleeve. As will be discussed in more detail later, the thinned region is preferably made by using a rotary cutter to cut an axially extending slot in the outer sleeve that does not extend through the entire outer sleeve. This permits a succession of laser welds in an axial direction in the slot to give dependable fusion between the ferrule and the outer sleeve. In a preferred embodiment, thinned regions are made on opposite sides of the outer sleeve and laser welding is performed simultaneously on both sides of the sleeve so as to avoid distortions caused by thermal stress asymmetries.

These and other objects, features, and advantages will be better understood from a consideration of the following detailed description taken in conjunction with the accompanying drawing.

Brief Description of the Drawing

FIG. 1 is a sectional view illustrating a method for laser welding an outer sleeve to a fiber ferrule;
FIG. 2 is a sectional view illustrating a method for laser welding an outer sleeve to a fiber ferrule in accordance with an illustrative embodiment of the invention;
FIG. 3 is a top view of the assembly of FIG. 2.

Detailed Description

Referring now to FIG. 1, there is shown an optical fiber 11 mounted within a cylindrical ferrule 12. The ferrule 12 is used to permit the fiber to be attached to other elements and is typically securely bonded to the fiber with an epoxy adhesive. For the fiber to be mounted in an optical coupler, it is typically necessary to slidably mount the ferrule 12 within a metal sleeve 14. The sleeve 14 is then mounted to the coupler (not shown).

Such mounting in the coupler normally requires that the fiber be positioned or aligned properly in both the axial and the rotational directions. This can best be done by first sliding the fiber ferrule axially to a proper position within the sleeve 14 and then permanently bonding the sleeve 14 and the ferrule 12. Thereafter, the sleeve, ferrule and fiber can be rotated as a unit for proper rotational alignment. It has been found that, after axial alignment, the best method for bonding the sleeve to the ferrule is by laser welding. As described in the U.S. Patent of Cruickshank et al., No. 4,733,047, granted March 22, 1988, and assigned to the American Telephone and Telegraph Company, which is incorporated herein by reference, laser welding of small parts that have to be

maintained in proper alignment is best done by splitting the laser beam and delivering it by two optical fibers so as to permit simultaneous welding on opposite sides of the article. In FIG. 1 laser welds 15 and 16 are simultaneously made by two laser beams delivered from a common pulsed laser.

A major problem we have encountered in making the assembly shown in FIG. 1 is the difficulty of making welds 15 and 16 so that they reliably fuse together the sleeve 14 and ferrule 12. Any slight misalignment of the laser beam will cause inadequate melting of either the sleeve or the ferrule. It is not practical to fuse through the entire thickness of sleeve 14 because the heat and power required for such operation would distort the alignment of the various elements.

Referring to FIG. 2, in accordance with one embodiment of the invention, these problems are solved by forming thinned regions 18 and 19 on opposite sides of the annular sleeve 14. This makes it possible to form laser welds 21 and 22 on opposite sides of sleeve 14, which dependably extend through the sleeve to fuse portions of ferrule 12, as required for bonding the ferrule to the sleeve. As in FIG. 1, each of the welds 21 is made simultaneously with a weld 22 on the opposite side of the sleeve. This is preferably done by using the laser beam transmission system described in the aforementioned Cruickshank et al. patent for making simultaneous welds that produce thermal stresses that are symmetrical and thereby less likely to deform the elements. The laser beams are taken from a single laser and delivered via optical fibers 23 to the weld sites. With the thinning of the outer sleeve and with simultaneous welding in this manner, we have found that welds 21 and 22 dependably can be made with a sufficiently low power laser beam to avoid harmful thermal stresses on the elements. Further, the laser beams do not damage the fiber 11 or vaporize the epoxy adhesive, which would also be harmful to the light transmission properties of the fiber. A top view of the FIG. 2 assembly is shown in FIG. 3 which shows the three laser welds 21 within thinned portion 18.

All of the elements of FIG. 2 are dimensionally quite small: optical fiber 11 may have a diameter of 0.1 cms (0.04 inch); the outer diameter of ferrule 12 may be 0.3 cms (0.120 inch); the outer diameter of sleeve 14 may be 0.43 cms (0.170 inch); the axial length of sleeve 14 may be 0.726 cms (0.286 inch). Welds 21 and 22 may have center-to-center spacings of 0.064 cms (25 mils) (0.025 inch). Successive welds in a straight line made in this manner are quite easy to perform using known pulsed laser techniques. On the other hand, making successive welds around a circular interface as shown in FIG. 1 is technically much more difficult. The laser may typically be a neodymium: yttrium-aluminum-garnet (Nd:YAG) pulsed laser having a nominal 50 watt rating that delivers five joules per pulse to each weld site, with each pulse having a duration of five milliseconds. A single pulse gives adequate penetration under these circumstances to give a dependable weld as shown. As is known, a laser pulse delivered by an optical fiber 23 tends to give somewhat deeper penetration than would otherwise be true.

The thinned portions 18 and 19 may be made by using a rotary cutter known in the art as a Woodruff cutter having a typical radius of 1.09 cms (0.43 inches). During cutting, the plane of the rotary cutter is parallel to the central axis of sleeve 14, making the thinned regions in the shape of slots as shown in FIG. 3. This reduces the wall thickness of the sleeve 14 typically from 0.064 cms (0.025 inch) to a value typically between 0.0254 cms (0.010 inch) and 0.036 cms (0.014 inch). Forming the thinned regions in this manner is quite convenient since it permits the sleeves 14 to be made of stock material which are then individually cut on opposite sides. Cutting in this manner has been found not to interfere with the ability to mount outer sleeve 14 within the optical coupler for subsequent rotational alignment as was described before.

A particular advantage of the invention as shown in FIGs. 2 and 3 is that it is amen ble to mass-production techniques. That is, the thinned portions 18 and 19 can be machined automatically, and three successive welds on opposite sides can be formed automatically on a production line after axial positioning. This is an important consideration because many optical couplers would have to be mass produced in conjunction with any complex optical fiber communication system production program.

The embodiments shown are intended to be merely descriptive of the principles of the inventive concept. While the invention was stimulated by a need to fix optical fiber ferrules to outer sleeves, the disclosed technique may be used in any environment in which laser welding is needed to fix together relatively small parts.

Claims

1. A method of assembling an optical apparatus comprising the steps of: mounting an optical fiber ferrule (12) within a metal sleeve (14) having a central axis; orienting the ferrule within the sleeve to attain a desired orientation of the optical fiber (11) with respect to the sleeve; and using a laser beam to weld permanently the ferrule to the sleeve; wherein: prior to the mounting, a region (18) of the sleeve is made significantly thinner than the remainder of the sleeve; the thinned region having an axial length shorter than the axial length of the sleeve, and the welding step comprises the step of directing the laser beam at the thinned portion of the sleeve characterized in that the thinned region is formed to have a width

transverse to its length much shorter than the circumference of the sleeve, whereby, in any section taken transversely to the central axis, the thickness of the sleeve along a major portion of its circumference is equal to the thickness of the sleeve prior to the thinning step, and only a minor portion of such circumference is defined by a thinned region, thereby forming an axially extending slot.

2. The method of claim 1 wherein:
the step of making a portion of the sleeve significantly thinner comprises the step of using a rotary cutter to cut at least one slot in the metal sleeve.

3. The method of claim 1 wherein:
the thinned region has a longer axial length than its width, and a plurality of welds are made along a line substantially parallel to said central axis.

4. The method of claim 3 wherein:
prior to the mounting, two diametrically opposite regions (18, 19) of the sleeve are made thinner than the remainder of the sleeve;
and the welding step comprises the step of simultaneously directing laser beams at both thinned portions of the sleeve.

5. The method of claim 3 wherein:
a rotary cutter is used to cut the sleeve to make each of the two thinned portions;
and, during each such cutting operation, the rotary cutter is arranged in a plane that is parallel to the central axis of the sleeve.

6. The method of claim 4 wherein:
after the welding step, the sleeve is rotationally aligned within an optical coupler and fixed to the optical coupler.

Patentansprüche

1. Verfahren zum Zusammenbau einer optischen Einrichtung mit folgenden Schritten: Anbringen einer Glasfaserhülse (12) in einer Metallmuffe (14) mit einer Mittelachse; Orientieren der Hülse in der Muffe, um eine gewünschte Orientierung der Glasfaser (11) zur Muffe zu erreichen; und Verwenden eines Laserstrahls zum dauerhaften Verschweißen der Hülse mit der Muffe, wobei vor der Anbringung ein Gebiet (18) der Muffe bedeutend dünner als der Rest der Muffe gemacht wird, wobei das dünner gemachte Gebiet eine kürzere Axiallänge als die der Muffe aufweist, und der Schweißschritt den Schritt des Richtens des Laserstrahls auf den dünner gemachten Teil der Muffe umfaßt, dadurch gekennzeichnet, daß das dünner gemachte Gebiet so gebildet wird, daß es quer zu seiner Länge eine viel kürzere Breite als der Umfang der Muffe aufweist, wodurch in jedem Schnitt quer zur Mittelachse die Stärke der Muffe entlang eines Großteils ihres Umfangs gleich der Stärke der Muffe vor dem Verdünnungsschritt ist, und nur ein geringer Teil dieses Umfangs durch ein dünner gemachtes Gebiet definiert wird, wodurch ein sich axial erstreckender Schlitz gebildet wird.

2. Verfahren nach Anspruch 1, wobei der Schritt, einen Teil der Muffe bedeutend dünner zu machen, den Schritt der Verwendung einer Drehschneidemaschine zum Einschneiden mindestens eines Schlitzes in die Metallmuffe umfaßt.

3. Verfahren nach Anspruch 1, wobei die Axiallänge des dünner gemachten Gebiets größer ist als seine Breite, und entlang einer im wesentlichen parallel zur besagten Mittelachse liegenden Linie eine Mehrzahl von Schweißstellen hergestellt werden.

4. Verfahren nach Anspruch 3, wobei vor der Anbringung zwei diametrisch gegenüberliegende Gebiete (18, 19) der Muffe dünner als der Rest der Muffe gemacht werden, und der Schweißschritt den Schritt des gleichzeitigen Richtens von Laserstrahlen auf beide dünner gemachte Teile der Muffe umfaßt.

5. Verfahren nach Anspruch 3, wobei zum Schneiden der Muffe zur Herstellung jedes der zwei dünner gemachten Teile eine Drehschneidemaschine benutzt wird, und während die jeweiligen derartigen Schneideoperation die Drehschneidemaschine in einer zur Mittelachse der Muffe parallelen Ebene angeordnet ist.

6. Verfahren nach Anspruch 4, wobei sich die Muffe nach dem Schweißschritt in Rotationsausrichtung in einem optischen Koppler befindet und am optischen Koppler befestigt ist.

Revendications

1. Méthode d'assemblage d'un appareil optique comprenant les étapes consistant à : monter un coulant (12) de fibre optique à l'intérieur d'une bague métallique (14) comportant un axe central ; orienter le coulant à l'intérieur de la bague pour atteindre une orientation souhaitée de la fibre optique (11) par rapport à la bague ; et utiliser un rayon laser pour souder le coulant à la bague

d'une façon permanente ; dans laquelle : antérieurement au montage, une zone (18) de la bague est rendue significativement plus mince que le reste de la bague ; la zone amincie ayant une longueur axiale plus courte que la longueur axiale de la bague, et l'étape de soudure comprend l'étape consistant à pointer le rayon laser sur la partie amincie de la bague caractérisée en ce que la zone amincie est formée pour avoir une largeur transversale à sa longueur beaucoup plus courte que la circonférence de la bague, par lequel moyen, dans une section quelconque prise transversalement à l'axe central, l'épaisseur de la bague le long d'une partie principale de sa circonférence est égale à l'épaisseur de la bague antérieurement à l'étape d'amincissement, et seule une partie peu importante d'une telle circonférence est définie par une zone amincie, formant ainsi une encoche s'étendant axialement.

2. Méthode de la revendication 1 dans laquelle :
l'étape consistant à rendre une partie de la bague significativement plus mince comprend l'étape consistant à utiliser un couteau rotatif pour découper au moins une encoche dans la bague métallique.

3. Méthode de la revendication 1 dans laquelle :
la zone amincie a une longueur axiale plus longue que sa largeur, et une pluralité de soudures sont réalisées le long d'une ligne substantiellement parallèle audit axe central.

4. Méthode de la revendication 3 dans laquelle :
antérieurement au montage, deux zones diamétralement opposées (18, 19) de la bague sont rendues plus minces que le reste de la bague ;
et l'étape de soudure comprend l'étape consistant à pointer simultanément des rayons laser sur les deux parties amincies de la bague.

5. Méthode de la revendication 3 dans laquelle :
un couteau rotatif est utilisé pour découper la bague pour réaliser chacune des deux parties amincies ;
et, pendant chaque telle opération de découpe, le couteau rotatif est agencé dans un plan qui est parallèle à l'axe central de la bague.

6. Méthode de la revendication 4 dans laquelle :
après l'étape de soudure, la bague est alignée en rotation à l'intérieur d'un raccord optique et fixée au raccord optique.

FIG. 1

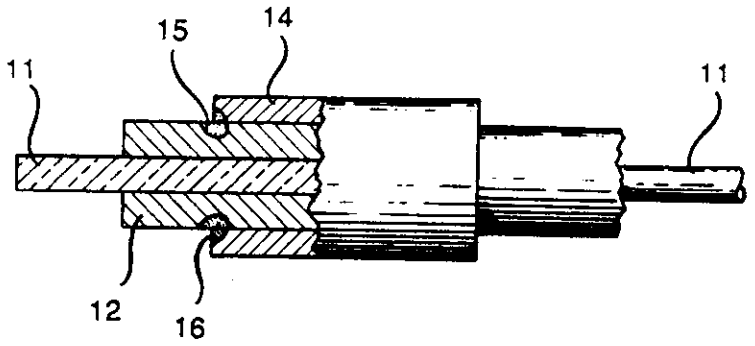


FIG. 2

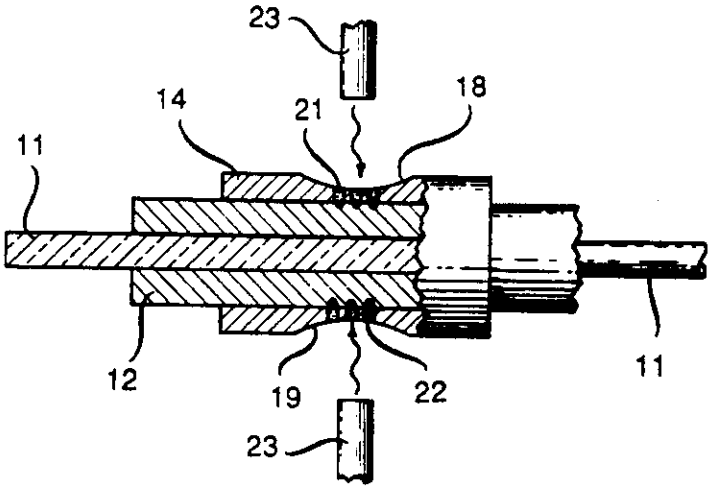
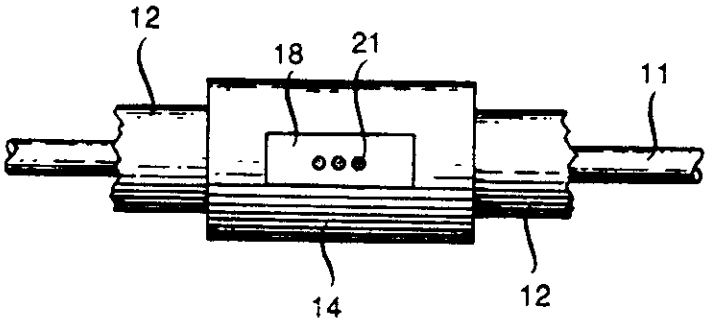


FIG. 3



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Title METHOD FOR WELDING RELATIVELY SMALL PARTS.

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