A method of forming a preform which has a glass core (10) surrounded by an outer glass cladding (16) with a coating (18) of an optically active material disposed between the core (10) and cladding (16). The method includes providing a glass core (10) having a viscosity which lies within a given preselected temperature range, followed by forming a substantially homogeneous coating (18) of an optically active material over the surface of the core, with the coating having a viscosity which is equal to or less than the viscosity of the glass core. A glass cladding (16) is formed over the coated layer (18), with the cladding (16) having a viscosity which overlaps the viscosity of the core glass (10) and a thermal coefficient of expansion compatible with that of the core. The optically active material is an inorganic material which includes a metal, metal alloy, ferrite, magnetic material or a semiconductor. The invention includes the product formed by the process.
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METHOD OF FABRICATING A CYLINDRICAL OPTICAL FIBER CONTAINING AN OPTICALLY ACTIVE FILM

This invention was made with government support under Grant No. F30602-96-C-0172 from the United States Air Force. Rome Laboratories. The government has certain rights in this invention.

Field of the Invention

This invention relates generally to a method of fabricating optical fibers, and more specifically to a method of fabricating optical fibers with a coating of an optically active material interposed between the cladding and core of the optical fiber.

Background Art

The technology of fiber optics is constantly changing. These technologies proliferate many technological areas including communications systems, sensors semiconductors, and laser technologies. Newly emerging areas employ fiber optics in a variety of ways. For example, fiber light amplifiers for fiber optic communications, fiber lasers for CD ROM applications, nonlinear fibers for optical switches, and fiber stress sensors in structure represent just a few of the applications of fiber optics.

Related art describes the fabrication of fibers which consist of a glass core covered with a glass tube or cladding that acts as a shield. The core serves to guide the light. Related art also describes coating the glass core with a film which is interposed between the glass core and the glass tube. The coatings used to produce the films can include various inorganic materials such as semiconductors, metals, alloys, magnetic materials, ferrites or ceramics. These films can be employed for a variety of purposes, considering the fact that properties of light traveling in the core can be modified by the presence of a specific coating. The related prior art however, fails to teach exactly how these fibers are to be fabricated when employing a wide variety of coating materials.
The fabrication of the fibers begins with the manufacture of a "preform". The "preform" is constructed by placing a micrometer or less coating on a glass rod which eventually becomes the core of the optical fiber. The coated rod is then placed inside of a larger diameter glass tube. In one case the glass tube is then sealed at one end to create a vacuum in the space between the coated rod and the tube. This assembly is then heated which causes the glass of the outer tube to collapse onto the coated rod. Additional glass tubes are collapsed on to this structure until the desired outside diameter of the preform is reached. This assembly is the "preform". Once the "preform" is constructed, it is then heated to a softening temperature of the glass, and fibers are drawn from the "preform". However, since the films are relatively thin, typically 10 nanometers or less, difficulty often arises when the fibers are drawn from the "preform" as the films tend to fracture and loose their continuity. The related prior art does not teach a reliable method of fabricating fibers which ensures that the continuity of the film layer is maintained as the fibers are drawn from the "preform". That is, the resulting film material only covers portions of the fiber due to breaks in the material. Moreover, the related art also fails to discuss a method for ensuring that the film layer will remain coherent and homogeneous during the drawing step.

In view of the above, there is a need in the art for a method of fabrication which ensures that the film layer maintains coherency, continuity and homogeneity as fibers are drawn from the "preform".

Summary of the Invention

Accordingly, it is a primary object of the present invention to provide a fabrication method for optical fibers that includes an optically active film on the core of the fiber, which ensures continuity of the film along the length of the fiber.

Still another object of the present invention is to provide a fabrication method which employs the use of optically active coatings which adhere homogeneously to the glass rod during the "preform" construction.
Still another object of the present invention is to provide a fabrication method which employs the use of optically active coatings, such as metals, non-metals, alloys, magnetic materials, semi-conductors, and other inorganic materials which do not vaporize or decompose when heated to the flow point temperature of the glass.

Still another object of the present invention is to provide a fabrication method which employs the use of optically active films which flow continuously and homogeneously at the glass rod/glass core interface during the fiber drawing process.

Yet another object of the present invention is to provide a fabrication method which employs the use of optically active coatings which will form a coherent, continuous film upon completion of the fiber drawing process.

Still another object of the present invention is to provide a fabrication method which results in an optical fiber with a film layer, located between the glass core and the glass shield, which modifies the properties of light traveling in the core.

Another object of the present invention is to provide a fabrication method which employs the use of optically active coatings in which the viscosity of the particular coating is less than the viscosity of the particular glass at the glass flow point temperature thereby allowing the coating to flow during the fiber drawing process.

Another object of the present invention is to provide a fabrication method which allows a partial coating of the core with a film layer. In some applications, it is desired to have only a small fraction of the core covered with an optically active film, yet that partial coating must be continuous along the optical fiber.

Another object of this present invention is to provide a fabrication method where the glass cladding and glass core are of a different composition.

Another object of the present invention is to provide a secondary inorganic coating over the optically coated “preform” core. The object is to prevent a low melting point coating material from dewetting the core at the “preform” collapse temperature.
These and other objects are accomplished by the method and resulting product of the present invention. The present invention is based upon the observations that during the fiber pulling process, the pressure in the glass can vary by a factor of several thousand from the point where the preform starts to the narrow to the point where the fiber diameter is reached. Consequently, in order for the film layer to maintain continuity, the plasto-viscosity properties of the coating material and the glass must be matched. As the film is pushed along (deformed) by the neighboring glass, which is softer than the film, its front edge is likely to dig in. As a result, the glass might stretch the film beyond its breaking point, thereby tearing the film.

Thus, the glass cannot be heated too much or it will be too soft during the drawing process. This makes it necessary to pull the fiber at the lowest temperature possible. Consequently, it is beneficial to conduct the fiber pulling process at temperatures where the film material is in a solid-liquid or liquid phase at the glass softening point. This provides the best assurance that the film will be soft and malleable so that it will deform smoothly when pulled.

The glass core for the present invention is selected such that its flow range lies within a preselected temperature range and is compatible with the cladding glass. Although the flow range depends upon the type of glass, it generally lies between about 600°C and 1500°C. The glass core material can be selected from any suitable glass, depending upon the application of the fiber that is produced. For example suitable glasses include, Pyrex, pure fused silica, and aluminosilicate glasses. The diameter of the glass core in the preform can also vary depending upon the application; however, they typically have an outside diameter of about 0.1 cm.

The coating is placed over the surface of the core, and eventually forms the film. The coating materials serves to modify the properties of the light traveling in the core. An appropriate coating material must remain coherent and continuous when drawn into the fiber, despite the fact that the film must be relatively thin. For instance, most films have a thickness of 10 nanometers for less. Consequently, the material selected for the coating must have a flow point which lies within the flow range for the glass. That is, the viscosity of the specific coating selected must match
the viscosity of the glass at the flow point temperature of the glass core material. To accomplish this, the optical material of the film is chosen which has a viscosity less than the core and cladding glass at the “preform” collapsing temperature and the fiber drawing temperature. Moreover, the coating material must be one that does not break down chemically, vaporize or adversely react when it comes into contact with the glass at this fabrication temperature. For example, Indium metal has a melting point of 156.2°C, yet is not significantly vaporized, nor does it react with glass at the glass flow points below 900°C. It should also be noted that the coating must also adhere well to the glass since it must remain in place homogeneously throughout the preform construction.

The coating material can be any suitable inorganic material such as either an alloy, a metal, non-metal, ceramic, ferrite, magnetic material or semiconductor material, and can be any species of one of those genera. These coating materials should have viscosities less than the viscosity of the core/cladding glass at the softening point of glass, and be capable of modifying the properties of light traveling in the core. In addition a number of multi component semiconductor systems meet the viscosity requirements. The resulting film serves as an interface between the core and the outer glass cladding. The film is substantially uniform over the entire surface of the glass core.

The glass cladding is formed over the interfacial film layer. The glass cladding material can be selected from any standard glass as well, such as those used for the core, depending upon the application of the fiber that is produced; however, the glass cladding must have a flow range which overlaps the flow range of the glass core material. Usually the core glass has a higher index of refraction than the cladding glass.

Three suitable pairings of core/cladding glass combinations which can be used in the present invention and their respective properties are tabulated below.
TABLE

Example #1

<table>
<thead>
<tr>
<th>Type of Glass</th>
<th>Type</th>
<th>Thermal Expansion Coeff.</th>
<th>Softening point C</th>
<th>Refractive Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Rod Glass Code 7056</td>
<td>Borosilicate</td>
<td>5.15E-06</td>
<td>702</td>
<td>1.487</td>
</tr>
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<td>Cladding Glass Code 7052</td>
<td>Borosilicate</td>
<td>4.60E-06</td>
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Example #2

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<th>Thermal Expansion Coeff.</th>
<th>Softening point C</th>
<th>Refractive Index</th>
</tr>
</thead>
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<td>Core Rod Glass Code 7251</td>
<td>Borosilicate</td>
<td>3.67E-06</td>
<td>780</td>
<td>1.476</td>
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<td>Cladding Glass Code 7760</td>
<td>Borosilicate</td>
<td>3.40E-06</td>
<td>780</td>
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Example #3

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<th>Type</th>
<th>Thermal Expansion Coeff.</th>
<th>Softening point C</th>
<th>Refractive Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Rod Glass Code 7052</td>
<td>Borosilicate</td>
<td>4.60E-06</td>
<td>712</td>
<td>1.484</td>
</tr>
<tr>
<td>Cladding Glass Code 7040</td>
<td>Borosilicate</td>
<td>4.75E-06</td>
<td>702</td>
<td>1.480</td>
</tr>
</tbody>
</table>

All of the above glasses are available from Corning under their respective code numbers listed in the table.
Brief Description of the Drawing

For a fuller understanding of the nature and objects of the invention, reference should be made to the following detailed description of a preferred mode of practicing the invention, read in connection with the accompanying drawings, in which:

FIG. 1 is a partially broken away perspective view illustrating a method for forming a preform of the present invention.

FIG. 2 is a side elevational view of a conventional drawing tower suitable for drawing a fiber made according to the present invention.

FIG. 3 is a side sectional view illustrating a method of making a preform of the present invention.

FIG. 4 is a side sectional view of the method illustrated in Fig. 3 with vacuum means and a traveling furnace.

FIG. 5 illustrates the transmission spectrum of an AlCu alloy strip fiber of the present invention.

FIG. 6 illustrates the transmission spectrum for the fiber preform of a CdTe film.

FIG. 7 is a perspective view of a dual fiber made in accordance with the present invention.

Detailed Description of the Invention

To achieve the foregoing and other objectives, a method of fabricating a "preform" according to the present invention is as follows. The method of fabrication results in a "preform" which consists of a glass core, a coating which eventually forms a thin film on the glass core, and a glass cladding which surrounds both the film and the core. This glass cladding acts as a shield, whereas the glass core serves to guide the light. The film serves to modify the properties of the light traveling within the core. The fibers are drawn from this "preform". A typical optical fiber has an outside diameter of about 125 micrometers, while the outside diameter of the core is about 10 micrometers.
In one embodiment, the preform can be made by forming a coating of semiconductor material 12 over a core rod 10 as illustrated in Fig. 1. The coated core rod is then inserted into a glass tube 14 that has been cleaned, closed at one end 18, and evacuated. The tube is then collapsed unto the coated core rod as shown at 16 in the drawing.

The fiber is drawn from the preform by any conventional fiber drawing tower apparatus known to the art. Figure 2 illustrates a fiber drawing tower 20 suitable for use in making fibers of present invention.

The top of the fiber drawing tower includes a motorized translation stage 22 which lowers the preform 24 at a rate of about 50 μm per sec. The horizontal position of the preform can be adjusted with an x-y translation stage 26 to align it with the center of the burner 28. The preform is held by a centering chuck 30. The burner heats the preform so that a fiber 32 can be drawn from it.

The fiber is drawn to the bottom of the fiber drawing tower emerging from the burner 28 passes over pulley 34 that is mounted on a lever arm 36. A weight 38 provides the required tension for the fiber and preform during the drawing process so that the core and cladding glass of the preform will smoothly extrude the optically active material layer. There is a counterbalancing weight 40 at the opposite end of the lever arm to balance the weight of the pulley. The capstan 42 pulls the fiber 32 between a belt 44 and stainless steel wheel 46.

In one embodiment of the present invention, as illustrated in Figs 3 and 4, the "preform" is fabricated by placing a 0.1 x 11 cm glass rod 50 into a 0.2 ID x 18 cm glass tube 52 which is sealed at one end 54 and evacuated from the other end. The sealed tube contains a few milligrams of an optically active material 58 placed at the sealed end of the tube (See Fig. 3). Coating of the rod with the optically active material is typically achieved by vacuum deposition using a traveling tube furnace 60 (Fig. 4) heated to the vapor point of the material and is moved from one end of the rod to be coated, i.e. starting from that end nearest the vacuum pump 62, to the opposite end of the rod nearest the material source (See Fig. 4). The furnace is of such length to envelope the entire rod and material source throughout deposition.
The furnace temperature also lies below the glass tube collapse point. After completing the deposition of the film layer 62, the ampoule is sealed at 64 the end near the vacuum system using a burner 66, removed from the furnace and allowed to cool to room temperature. The section containing the powder is then pinched off.

The advantage of this method of deposition is that the film never comes in contact with the air. However, this method, which employs a heater to evaporate the coating material, can only be used for materials that will evaporate at temperature below which the ampoule will collapse. Otherwise, an alternative coating method must be employed. For example, an optical deposition system that uses light with wavelength in the visible range. Optionally, light can be used to evaporate the coating without heating the ampoule glass. This method of evaporation is useful with semiconductors since glass is transparent to light, and the semiconductors absorb the light. Specifically, an argon laser operating at 2.25 W can be used to evaporate a Ge semiconductor in a sealed, evacuated Pyrex ampoule. Since glass is a poor conductor, the ampoule is heated more than the glass core, and is collapsed onto the core. A flame is first used to preheat the structure to a temperature below the working temperature of the glass, so that both the glass rod and ampoule will start from the same temperature during the cooling process after the ampoule has been collapsed. This is accomplished by slowly moving the burner along the glass ampoule. If this is not done either the ampoule or the core rod will crack. After preheating the ampoule and rod, the temperature of the ampoule is increased by bringing the burner flames closer to the glass ampoule. The ampoule is collapsed by propagating the burner along the structure. The collapsing process "traps" the optically active material without ever exposing it to air. The collapsed ampoule is then placed into another glass tube that has been closed at one end. The open end of the tube is connected to a vacuum pump, while the closed end is placed in another traveling furnace. The furnace is slowly moved to cover the tube. As the tube is heated it begins to collapse onto the closed ampoule. The tube will collapse starting from the end furthest from the vacuum pump. This process is repeated until the
required outside diameter or cladding of the fiber preform is reached. The "preform" construction is then complete. The fibers are then pulled from this preform.

During the fiber pulling process the pressure in the glass can vary by a factor of several thousand from the point where the preform begins to flow to the narrow point where the fiber diameter is reached. Consequently, in order for the film layer to maintain continuity, the plasto-viscosity properties of the coating material and the glass must be matched. As the film is pushed along (deformed) by the neighboring glass, which is softer than the film, its front edge is likely to dig in. As a result, the glass might stretch the film beyond its breaking point, thereby tearing the film.

Thus, the glass cannot be heated too much or it will be too soft during the drawing process. This makes it necessary to pull the fiber at the lowest temperature possible. Consequently, it is beneficial to conduct the fiber pulling process at temperatures where the film material that is in a liquid or solid-liquid phase at the glass softening point. This provides the best assurance that the film will be soft and malleable so that it will deform smoothly when pulled.

In the preferred embodiment the core is cylindrical in shape. The glass core is selected such that its flow range lies within a preselected temperature range. Although the flow range depends upon the type of glass, it generally lies between 600°C and 1500°C. The glass core material can be selected from any glass, depending upon the application of the fiber that is produced. For example, Pyrex, pure fused silica, and alumino-silicate glasses can be used. It is necessary for the fibers to have cores through which only a single mode propagates. The diameter of the glass core can also vary depending upon the application; however, they typically have an outside diameter of about 0.1 cm.

The coating is placed over the surface of the core, and eventually forms the film. The coating materials serves to modify the properties of the light traveling in the core. An appropriate coating material must remain coherent and continuous when drawn into the fiber, despite the fact that the film must be relatively thin. For example, most films have a thickness of about 10 nanometers for less.
Consequently, the material selected for the coating must have a flow point which lies within the flow range for the glass. That is, the viscosity of the specific coating selected must be less than the viscosity of the glass at the flow point temperature of the glass core material. In the event that the film material has a melting point below the softening point of the glass and a characteristic of dewetting glass at the melting point, the material coating on the glass rod can be coated with a second material with a higher melting point, e.g. powdered glass, which will hold the optically active material in place during "preform" collapse.

Moreover, the coating material must be one that does not break down, vaporize or react when it comes into contact with the glass. For example, Indium metal has a melting point of 156.2 °C, yet is not significantly vaporized, nor does it react with glass at glass flow points below 900 °C. It should also be noted that the coating must adhere well to the glass since it must remain in place homogeneously throughout the preform construction. Indium dewets glass at the collapse temperature; however, indium coating covered with a powdered glass mix at temperature below its melting point will survive the cladding collapse process without dewetting the core.

The coating can be any suitable inorganic material such as an alloy, a metal, ferrite, magnetic or semiconductor material, and can be any species of one of those genuses. These coating materials have flow points below the softening point of glass, and be capable of modifying the properties of light traveling in the core. In addition any multi component semiconductor systems which meet the viscosity requirements can be used in the present invention. More specifically, InSb and GaSb systems are continuous solids and have a significant liquid/solid phase within the 500 to 800 °C temperature range. In this range the viscosity of the semiconductor is adequate when the glass flow range lies in the same region.

The resulting film serves as an interface between the core and the glass tube. The film is substantially uniform over the surface of the glass core.

The glass cladding is formed over said interfacial film layer. The glass cladding material can be selected from any standard glass as well, depending upon
the application of the fiber that is produced, however, the glass cladding must have a
flow range which overlaps the flow range of the glass core material. In one
embodiment, the index of refraction of the core was slightly higher than the index of
refraction of the cladding.

5 The following example illustrate an embodiment of the present invention.

EXAMPLE

In one embodiment of the invention an AlCu alloy was used as the coating
layer. Cu has a melting point of 1086°C, while Al has a melting point of 660°C.
Consequently, the melting point of AlCu can be adjusted by selecting the
appropriate Al and Cu composition. Appropriate amounts of Cu and Al are selected
to yield the desired alloy. AlCu alloys with melting points ranging from 540°C to
1084°C can be fabricated.

The alloy was vapor deposited on a Corning 7740 glass rod. This rod has a
softening point of about 750 °C. Consequently, it was necessary to use an alloy
which contained between 35 and 100 percent aluminum. Preferably, due to a
chemical reaction between the glass and aluminum at the softening point of the
glass, higher copper concentrations should be used to reduce evaporation of the
alloy. Moreover, alloys that are in the liquid-solid phase are generally acceptable
since their viscosity allow the metal to flow during the fiber drawing process.

20 In a specific embodiment, a layer of the AlCu coating material was vacuum
deposited on a 1 mm diameter type 7720 Corning glass rod. The AlCu alloy
contained about 62% Cu and 38% Al by weight. The melting point of the alloy was
about 680 °C. The rod is inserted into a type 7052 Corning glass tube that was
closed at one end. The glass tube has a 3 mm outside diameter, and a 1.8 mm inside
diameter. The tube is then evacuated to 10⁻⁴ Torr., heated at about 250°C for two
hours, and sealed at the vacuum pump end to form a closed ampoule tube. The
ampoule tube is then collapsed. Other tubes are sequentially collapsed on to the
collapsed ampoule. This resulted in the formation of a 8.3 mm O.D. preform. In an
alternative method of fabrication, the ampoule can be collapsed under an external
pressure at about 650°C, and two Glass tubes can be sequentially collapsed onto the
collapsed ampoule to form the "preform". Additional tubing layers could be employed to achieve a necessary "preform" diameter.

The transmission spectrum of the AlCu alloy strip fibers described above were measured at room temperature using an unpolarized white light source. The data is shown in Fig. 5. Fiber samples about 30 cm long were used. Note the resonances at 449 nm, 935 nm, and 1140 nm. These resonances correspond to optical frequencies of $6.677 \times 10^{14}$ Hz, of $3.206 \times 10^{14}$ Hz, and of $2.630 \times 10^{14}$ Hz respectively. One application for this structure is the use as high dispersion fiber for pulse shape correction.

Cylindrical fibers with an optically active metallic film surrounding a cylindrical core can be used for dispersion correction, and light pulse reshaping. The thin, about 5 nm thick, metal film has entirely different properties than bulk metal. The thin metal layers have the properties of a dielectric layer with an index of refraction of about 90. This, results in Fabrey-Perot resonances in the metal layer.

At light frequencies near these resonant frequencies the fibers exhibit very large dispersion properties. Both positive and negative dispersion can be achieved depending on which side of the resonant frequency the fiber is operated. At these resonances the fibers are dissipative. However, the dispersion maxima occur at light frequencies to either side of the resonant frequency where the losses are minimal.

The resonant frequencies depend on the thickness of the metal film. Thus, by controlling the metal film thickness, the light frequencies at which the high dispersion with the appropriate sign occurs can be determined. These to are inexpensive to fabricate since a very large number of high dispersion fiber sections can be made from a single preform.

Another sample was made with a CdTe semiconductor at the core cladding boundary. These fibers had a core diameter of 10 $\mu$m and a smooth uniform semiconductor layer. Since the core diameter is near single mode the interaction is much stronger. Also that this time the transmission spectrum does exhibit a blue shift due to the quantum size effect of the very thin, approximately 5 nm thick, semiconductor layer.
We, first, measured the transmission spectrum of the fiber preform. The fiber preform exhibits a step at a wavelength of 827 nm in the transmission spectrum as shown in Fig. 6. This is in agreement with its value in bulk crystalline CdTe. The step is relatively sharp having a width of only 1.7 kT. Measurements were performed at room temperature.

The primary application of the semiconductor cylinder fiber (SCF) is as a fiber light amplifier (FLA). It has the following advantages over present doped glass FLAs: it can be pumped with broad spectral light such as light from a light emitting diode (LED). Since the semiconductor cylinder fiber light amplifiers (SCFLA) are only about 5 mm long they can be pumped from the side rather than requiring input and output couplers, and a laser to focus light into the single mode core of the FLA. They are inexpensive to fabricate since a very large number of SCFLAs can be made from a single preform. Since each device is only about a few mm long 200,000 SCFLAs can be obtained from 1 km of fiber run. This is similar to the semiconductor integrated circuit fabrication process where a large number of devices can be made from a single wafer.

Another application for the semiconductor film is as non linear fiber. Fibers with non linear characteristics can be used in high speed optically activated optical switches. The SCFs have much larger non linear characteristic than conventional fibers.

Another embodiment of a useful fiber configuration are fibers with two cores. The preforms for the two coated core fibers are fabricated as follows:

In one embodiment, two individual preforms are constructed. Each preform consists of two 7440 Pyrex glass tubes that are successively collapsed onto a type 3320 2.1 mm diameter glass rod. This forms two 6.3 mm diameter preforms. The preforms are mounted next to each other on a wooden block. The wood block is clamped to the sliding platform of a glass cutter. Two glass cutting wheels forming a dado cutter are mounted on the shaft of the glass cutter. The preform and wood support are moved into the path of the dado cutter. The stacked glass cutting wheels cut a dado between the two preforms. The resulting flat surface of each preform can be polished if necessary. The flat surfaces of the two “D” shaped preforms are
coated with a suspension of type 7440 glass powder in an organic binder. The flat surfaces of the "D" shaped preform are pressed together and heated. This fuses the two "D" shaped preforms into a single two core preform. A fiber is then drawn form this preform. The spacing between cores can readily be adjusted in the dado cutting process. An "Isolator" can be fabricated by surrounding both cores with a poled non absorbing magnetic material.

A perspective view of the resulting fiber 60 is illustrated in Fig. 7 in which the dual cores 62 and 64 are surrounded by their respective outer claddings 66 and 68. Core 64 contains a coating 65 of optically active material, and large uncoated core 62 functions to supply pump light to amplifying core 64-65.

In a further embodiment, a composite structure can be made by depositing an In layer on the glass rod followed by a thicker alloy layer, followed by another In covering layer.

The fibers can be smoothly drawn from these "preforms". In all cases the fibers have a continuous interfacial layer.

While the present invention has been particularly shown and described with reference to the preferred mode as illustrated in the drawing, it will be understood by one skilled in the art that various changes in detail may be effected therein without departing from the spirit and scope of the invention as defined by the claims.

Accordingly, the drawing and description are to be regarded as illustrative in nature, and not as restrictive.
What is claimed is:

1. A method of forming an optical fiber from a preform having a glass core surrounded by an outer glass cladding with a coating of an optically active material between said core and cladding, said method comprising:
   (a) providing a preform which includes a glass core having a viscosity which lies within a given preselected temperature range with a substantially homogeneous coating of an optically active material over the surface of said core with said coating material having a viscosity which is equal to or less than the viscosity of said glass core; and a glass cladding over said coated layer, with said glass having a viscosity which overlaps the viscosity of the glass core material and a coefficient of thermal expansion compatible with that of the core; and
   (b) drawing a fiber from the preform of (a).

2. The method of claim 1 in which the optically active coating comprises an inorganic material.

3. The method of claim 1 is in which the optically active material is an inorganic material selected from the group consisting of a metal, metal alloy, ferrite, magnetic material and a semiconductor.

4. The method of claim 1 in which the optically active material comprises a metal or a metal alloy.

5. The method of claim 1 in which the optically active material comprises an AlCu alloy.

6. The method of claim 1 in which the optically active material comprises a semiconductor.

7. An optical fiber having a glass core surrounded by an outer glass cladding with a coating of an optically active material between said core and cladding with said glass core having a viscosity which lies within a given preselected temperature range with a substantially homogeneous coating of an optically active material over the
surface of said core with said coating material having a viscosity which is equal to or
less than the viscosity of said glass core; and a glass cladding over said coated layer,
with said glass having a viscosity which overlaps the viscosity of the glass core
material and a coefficient of thermal expansion compatible with that of the core.

8. The fiber of claim 7 in which the optically active coating comprises an
inorganic material.

9. The fiber of claim 7 is in which the optically active material is an inorganic
material selected from the group consisting of a metal, metal alloy, ferrite, magnetic
material and a semiconductor.

10. The fiber of claim 7 in which the optically active material comprises a metal or
a metal alloy.

11. The fiber of claim 7 in which the optically active material comprises an AlCu
alloy.

12. The fiber of claim 7 in which the optically active material comprises a
semiconductor.
NORMALIZED TRANSMISSION IN dB

WAVELENGTH IN nm

FIG. 6
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
   IPC(6) : G02B 6/22; H01S 3/30
   US CL : 385/123, 124, 128, 144; 372/6; 65/412, 445
   According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
   Minimum documentation searched (classification system followed by classification symbols)
   U.S. : 385/122, 123, 124, 128, 141, 142, 144; 372/6; 65/412, 445; 359/341

   Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
   NONE

   Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
   NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>A</td>
<td>US 5,642,454 A (KOPYLOV ET AL) 24 June 1997 (24/06/97), see columns 3-5.</td>
<td>1-6</td>
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<tr>
<td>A</td>
<td>US 5,485,480 A (KLEINERMAN) 16 January 1996 (16/01/96), see entire document.</td>
<td>7-12</td>
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</table>

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:
   "A" document defining the general state of the art which is not considered to be of particular relevance
   "E" earlier document published on or after the international filing date
   "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
   "O" document referring to an oral disclosure, use, exhibition or other means
   "P" document published prior to the international filing date but later than the priority date claimed

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

document member of the same patent family

Date of the actual completion of the international search
24 OCTOBER 1999

Date of mailing of the international search report
04 NOV 1999

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Form PCT/ISA/210 (second sheet) (July 1992)