

A METHOD FOR PRODUCING A GLASS PREFORM
FOR AN OPTICAL FIBRE

The present invention relates to a method for producing a glass preform for an optical fibre, and in particular
5 a method which uses at least two burners.

One known method for producing a glass preform for an optical fibre is a vapour phase method in which a mixture of a fuel gas, a glass raw material and optionally an additive for adjusting a refractive index of the glass preform produced are jetted from a burner. The glass raw material is
10 hydrolyzed in an oxyhydrogen flame to synthesize fine glass particles. The fine glass particles are deposited on a rotating starting member to form a porous soot preform and then the porous soot preform is heated and sintered to
15 obtain a transparent glass preform. Usually, the fuel gas is a mixture of hydrogen and oxygen, the glass raw material is SiCl_4 , and the additive is e.g. GeCl_4 , POCl_3 , BBr_3 , etc. To increase the production rate and the size of the porous soot preform, two or more burners may be used in the vapour
20 phase method.

Hitherto, when two or more burners are used in the conventional vapour phase method, it is rather difficult to control the bulk density of the mass of fine glass particles deposited in the periphery of the soot preform and to
25 increase the yield.

Usually, the first centre burner forms a flame which encloses a central part of a surface of the soot preform on which the fine glass particles are being deposited (hereinafter referred to as "depositing surface"). However, the
5 second burner or burners can heat only a part of the depositing surface since its flame cannot enclose the whole depositing surface. This is shown in Fig. 1 of the accompanying drawings: in which two burners 11 and 12 are used, the burner 11 forming a centre portion of the porous soot
10 preform and burner 12 forming a peripheral portion of the soot preform. Regions 13 and 14 are heated by the burners 11 and 12, respectively. Since the soot preform is raised and rotated simultaneously, there is a delay in heating some peripheral portions so that the depositing surface is not
15 heated sufficiently. Thus, the bulk density of the glass particle mass deposited in the peripheral portion becomes low, which tends to cause cracks.

When the width of the flame is increased to increase the bulk density of the glass particles deposited on the
20 periphery of the soot preform, the convergence of the flame is decreased and the temperature of the centre of the flame is reduced, causing a deterioration in the rate of production of the glass particles. Alternatively the temperature of the fine glass particles may not be raised sufficiently,
25 which results in a decrease in the yield. When the rate of flow of the hydrogen is increased so as to raise the temperature of the flame and hence the temperature of the

depositing surface, interference between the burners induces a minimum point in a bulk density distribution as shown in Fig. 2 of the accompanying drawings, which causes cracks in the porous soot preform.

5 Thus, when two or more burners are used for synthesizing the fine glass particles in the production of the porous soot preform, the shape and flow rate of the flame produced by the second burner(s) 12 are selected so that the reaction rate of the glass raw material may be increased,
 10 the temperature of the fine glass particles may be raised, and the yield of the fine glass particles may be improved. Simultaneously the flame(s) formed by the burner(s) is controlled so as to obtain a stable distribution of the bulk density of the porous soot preform.

15 When SiCl_4 is used as the raw material of the glass, the fine glass particles are synthesized according to the following equation:



Although this reaction is exothermic, it should be promoted
 20 by heat evolved by the oxyhydrogen flame since its reaction heat is only 24 kcal/mol. Thus, the rate of synthesis of the fine glass particles depends on the amount of heat conducted from the flame and, consequently, the temperature distribution in the stream of the fine glass particles
 25 depends on the heat of the flame. When SiCl_4 is used alone as the glass raw material, the flame formed by the burner contributes to the synthesis of the fine glass particles,

heating of the synthesized fine glass particles and heating of the depositing surface of the porous soot preform. Therefore, the conditions under which a stable, large, porous soot preform is produced with good yield and any one of the above described drawbacks is not encountered are very restricted.

The present invention seeks to overcome, or at least ameliorate, these problems, and thereby make possible the production of a large, stable, porous soot preform which has a bulk density which can be controlled easily. The invention achieves this by providing a method for producing a glass preform for an optical fibre having a core part and a cladding part by means of separate burners, comprising jetting a first glass raw material containing SiCl_4 from a first burner and a second glass raw material containing SiHCl_3 , SiH_2Cl_2 , SiH_3Cl and/or SiH_4 from a second burner, flame hydrolyzing the glass raw material to synthesizing fine glass particles, depositing the fine glass particles on a starting member to form a porous soot preform and heating and sintering the soot preform to obtain a transparent glass preform, wherein the first burner is used to form the core part and the second burner is used to form the cladding part, and the particles are deposited in the direction of the axis of the starting member. In this way the deposition yield of the glass raw material may be improved.

Embodiments of the invention will now be described in

detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 schematically shows a method for synthesizing and depositing fine glass particles in which two burners are used, and has already been discussed;

Fig. 2 shows the bulk density distribution in a radial direction of a porous soot preform produced by a conventional vapour phase method, and has already been discussed;

Fig. 3 shows the relationship between an amount of a glass raw material and a deposition yield; and

Figs. 4 and 5 show bulk density distributions in a radial direction of the porous soot preforms produced in Example 1 and a Comparative Example, respectively.

Specific examples of a hydrogen-containing silicon compound with larger reaction heat than SiCl_4 are SiHCl_3 , SiH_2Cl_2 , SiH_3Cl and SiH_4 . These compounds may be used as may a mixture of two or more of them. Further, the

10 hydrogen-containing silicon compound may be used when mixed with SiCl_4 . For example, hydrolysis or combustion of SiHCl_3 and SiH_4 may proceed as follows:



15 The reaction heat of reactions II and III are 118 kcal/mol and 339 kcal/mol, respectively, and are both far larger than heat of hydrolysis of SiCl_4 and large enough for the reactions to be continuous. Therefore, when such a hydrogen-containing silicon compound is used as the glass raw

20 material, the synthesis of the fine glass particles does not require combustion heat from the fuel gas and hence the fine glass particles can be heated to a sufficiently high temperature. The combustion heat can be used predominantly to heat the surface of the deposited glass particles and thus

25 the bulk density of the porous soot preform is easily controlled irrespective of the reaction of the glass raw material. As the result, the rate of deposition of the fine

glass raw material may be increased.

According to the method of the present invention, the first (centre) burner may be used to form a core part having a higher refractive index, and the second burner(s) may be used to form a cladding part having lower refractive index.

In the present invention, the jetting rates of the fuel gas, the glass raw material and the (optional) additive are substantially the same as in a conventional vapour phase method, such as a vapour phase axial deposition method.

The heating and sintering of the porous soot preform is carried out in a conventional manner, for example, at a temperature of at least 1,600°C in an atmosphere of an inert gas (e.g. helium). In the sintering step, an additive (e.g. SF₆, CF₄, CCl₂F₂, SiF₄, BF₄, BCl₃, etc.) may be added to adjust the refractive index of the transparent glass preform. The additive may be jetted from either the first or second burner or from both burners.

The present invention will hereinafter be explained further in detail with reference to some examples.

Comparative Example

Using the burners 11 and 12 as shown in Fig. 1, a porous soot preform was produced from SiCl₄. The burners 11 and 12 were identical coaxial multi-nozzle burners.

The flow rates of the burners 11 and 12 were as follows:

Burner 11

(for the centre part of the preform)

	SiCl ₄	600	ml/min.
	GeCl ₄	105	ml/min.
	Hydrogen	10	l/min.
	Oxygen	12	l/min.
5	Argon	2.7	l/min.

Burner 12

(for the peripheral part of the preform)

	Hydrogen	20	l/min.
	Oxygen	20	l/min.
10	Argon	4	l/min.
	SiCl ₄	340, 600, 820 or 1,100	ml/min.

The deposition yields (amount of glass particles actually deposited/theoretical amount to be deposited based on the jetted amount of the glass raw material) of the porous soot preforms are shown in Fig. 3 by open circles. In Fig. 3, the flow rate of SiCl₄ is calculated as SiO₂.

As is seen from Fig. 3, the deposition yields scatter between 50 and 60%. When the flow rate of SiCl₄ from the second burner was 1,100 ml/min., the soot preform cracked and was not produced in a stable way. In this case, the bulk density distribution was unstable as shown in Fig. 4 and had a minimum point.

Example 1

A soot glass preform was produced in the same manner as in Comparative Example but jetting SiHCl₃ from the second burner 12 at the following flow rates:

Hydrogen	12	l/min.
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Oxygen 20 l/min.
 Argon 4 l/min.
 SiHCl₃ 340, 970, 820, 1,100 or 1,120 ml/min.

The deposition yields are shown in Fig. 3 as solid circles, and it can be seen that the yields are about 10% larger than those in the Comparative Example and scatter between 56 to 68%.

In this example, when SiHCl₃ was jetted at 1,100 ml/min or higher, the porous soot preforms were stable. The bulk density distribution is smooth and stable as shown in Fig. 5.

Example 2

A porous soot preform was produced in the same manner as in the Comparative Example but with flowing the gases at the following rates:

Burner 11

SiCl₄ 600 ml/min.
 GeCl₄ 105 ml/min.
 Hydrogen 10 l/min.
 Oxygen 12 l/min.
 Argon 2.7 l/min.

Burner 12

Hydrogen	16	l/min.
Oxygen	20	l/min.
Argon	4	l/min.
SiCl ₄	600	ml/min.
SiHCl ₃	340	ml/min.

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The deposition yield was 61%.

CLAIMS:

1. A method for producing a glass preform for an optical fibre having a core part and a cladding part by means of separate burners, comprising jetting a first glass raw material containing SiCl_4 from a first burner and a second glass raw material containing SiHCl_3 , SiH_2Cl_2 , SiH_3Cl and/or SiH_4 from a second burner, flame hydrolyzing the glass raw material to synthesizing fine glass particles, depositing the fine glass particles on a starting member to form a porous soot preform and heating and sintering the soot preform to obtain a transparent glass preform, wherein the first burner is used to form the core part and the second burner is used to form the cladding part, and the particles are deposited in the direction of the axis of the starting member.
 2. A method according to claim 1, wherein the core part of the porous preform has a higher refractive index than the cladding part.
 3. A method for producing a glass preform for an optical fibre substantially as herein described with reference to Example 1 or Example 2.
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