FILTER AND MANUFACTURING METHOD THEREOF, AND LASER WAVELENGTH MONITORING DEVICE

Disclosed are a filter, a method for producing a filter, and a laser wavelength monitoring apparatus, where the filter includes: two translucent bodies, where each of the translucent bodies has a first plane, a second plane that forms a wedge angle with the first plane, and a third plane that intersects with both the first plane and the second plane, first planes of the two translucent bodies are parallel to each other, and second planes of the two translucent bodies are parallel to each other; a beam splitting film, where surfaces of both sides are respectively combined with the first planes of the two translucent bodies; and two reflective films, respectively combined with the second planes of the two translucent bodies. A wavelength monitoring optical path of the laser wavelength monitoring apparatus in the solutions is significantly shortened compared with that in the prior art, a volume of the laser wavelength monitoring apparatus is relatively small, and miniaturized packaging can be implemented, which significantly reduces packaging costs of a product. In addition, monitoring precision is relatively high.
TECHNICAL FIELD

[0001] The present invention relates to the field of optical fiber communications technologies, and in particular, to a filter, a method for producing a filter, and a laser wavelength monitoring apparatus.

BACKGROUND

[0002] With continuous growth of a user's requirement for bandwidth, a conventional copper wire broadband access system is increasingly confronted with a bandwidth bottleneck. At the same time, an optical fiber communications technology with a massive bandwidth capacity is increasingly mature, and an optical fiber access network becomes a strong competitor of a next-generation broadband access network. In particular, a PON (passive optical network, passive optical network) system is more competitive.

[0003] In the PON system, an optical module is used as a physical entity for implementing a transceiver system, and a function of the optical module is of great importance; a laser is used as a transmission apparatus of a communication lightwave, a function of the laser is a top priority. In many application scenarios of a PON field, a transmit wavelength of a laser device needs to be stable at a specific value, so as to ensure that technical specifications of physical transmission and an optical communication standard are met. Therefore, in many application scenarios, a laser in an optical module generally has a semiconductor cooler or a heating membrane used to adjust a wavelength, and a laser wavelength monitoring apparatus needs to be used to implement a feedback adjustment.

[0004] As shown in FIG. 1, a prior laser wavelength monitoring apparatus includes a collimation lens 1, a first focusing lens 2, an F-P etalon 3, two beam splitters 4a and 4b, two optical receivers 5a and 5b, and two second focusing lenses 6a and 6b, where the F-P etalon 3 functions as a comb filter, and the two beam splitters 4a and 4b each are a beam splitter that has a fixed split ratio. Light emitted by a laser 7 becomes collimated light after passing through the collimation lens 1. The beam splitter 4a divides the collimated light according to a specific ratio, where one part of the light is received by the optical receiver 5a after passing through the second focusing lens 6a, and the other part of the light is incident into the F-P etalon 3 after passing through the beam splitter 4a. The beam splitter 4b divides, according to a specific ratio, light that penetrates the F-P etalon 3, where one part of the light is received by the optical receiver 5b after passing through the second focusing lens 6b, and the other part of the light passes through the beam splitter 4b, and then is incident into an incident port 8 of a transmit fiber after passing through the first focusing lens 2.

[0005] It is assumed that PD10 and PD20 are respectively initially calibrated optical powers of the two optical receivers 5a and 5b, PD1 and PD2 are respectively actual received optical powers of the two optical receivers 5a and 5b, and a ratio of the actual received optical power of the optical receiver 5b to that of the optical receiver 5a is $A = PD2/PD1$. When a redshift occurs in a laser wavelength, $PD2 = PD20 + \Delta P$, and when a blueshift occurs in the laser wavelength, $PD2 = PD20 - \Delta P$; PD1 does not vary with the laser wavelength. Therefore, a wavelength offset is:

$$\Delta A = +\Delta P/PD10 \, \text{(redshift)}, \quad \Delta A = -\Delta P/PD10 \, \text{(blueshift)} \quad (1)$$

[0006] Therefore, a change status of a laser wavelength may be defined according to the wavelength offset $\Delta A$.

[0007] The inventor of the present patent application finds that because of two beam splitters, an overall packaging size of a laser wavelength monitoring apparatus is relatively large, and packaging costs are relatively high, which does not accord with a current development tendency of miniaturization and low costs. In addition, monitoring precision of a laser wavelength monitoring apparatus of this structure is not high enough.

SUMMARY

[0008] Embodiments of the present invention provide a filter, a method for producing a filter, and a laser wavelength monitoring apparatus, so as to reduce a volume and costs of a laser wavelength monitoring apparatus and further improve monitoring precision.

[0009] According to a first aspect of the present invention, a filter is provided, including two translucent bodies, where each of the translucent bodies has a first plane, a second plane that forms a wedge angle with the first plane, and a third plane that intersects with both the first plane and the second plane, first planes of the two translucent bodies are parallel to each other, and second planes of the two translucent bodies are parallel to each other; a beam splitting film, where surfaces of both sides are respectively combined with the first planes of the two translucent bodies; and
two reflective films, respectively combined with the second planes of the two translucent bodies.

[0010] In a possible implementation manner of the first aspect, the wedge angle is $45^\circ \pm \lambda$, and $\lambda$ is a set allowable error.

[0011] In a possible implementation manner of the first aspect, third planes of the two translucent bodies are parallel or not parallel.

[0012] In a possible implementation manner of the first aspect, in the two translucent bodies, one of the translucent bodies includes at least two translucent substrates, where an antireflection coating is disposed between two adjacent translucent substrates.

[0013] According to a second aspect of the present invention, a method for producing the filter according to any one of the foregoing technical solutions is provided, including: plating a reflective film separately on second planes of two translucent bodies, and plating a beam splitting film on a first plane of one of the translucent bodies; and combining a first plane of the other translucent body with the beam splitting film.

[0014] In a possible implementation manner of the second aspect, the combining a first plane of the other translucent body with the beam splitting film is specifically:

bonding the first plane of the other translucent body to the beam splitting film.

[0015] According to a third aspect of the present invention, a laser wavelength monitoring apparatus is provided, including two optical receivers and the filter according to any one of the foregoing technical solutions, where:

the two reflective films of the filter respectively face a transmit port of a laser and an incident port of a transmit fiber, and the two third planes of the filter respectively face receive ports of the two optical receivers.

[0016] In a possible implementation manner of the third aspect, the laser wavelength monitoring apparatus further includes a collimation lens located between the transmit port of the laser and the reflective film that is of the filter and faces the transmit port of the laser.

[0017] In a possible implementation manner of the third aspect, one side of the collimation lens is a plane and is combined with the reflective film that is of the filter and faces the side of the collimation lens.

[0018] In a possible implementation manner of the third aspect, the laser wavelength monitoring apparatus further includes a first focusing lens located between the incident port of the transmit fiber and the reflective film that is of the filter and faces the incident port of the transmit fiber.

[0019] In a possible implementation manner of the third aspect, one side of the first focusing lens is a plane and is combined with the reflective film that is of the filter and faces the side of the first focusing lens.

[0020] In a possible implementation manner of the third aspect, the laser wavelength monitoring apparatus further includes two second focusing lenses, respectively located between the two third planes of the filter and the receive ports that are of the optical receivers and face the two third planes of the filter.

[0021] In a possible implementation manner of the third aspect, in the filter, a translucent body that includes at least two translucent substrates is located on one side that is of a beam splitting film and is close to the incident port of the transmit fiber.

[0022] In technical solutions of the embodiments of the present invention, a beam splitting film is disposed between first planes of two translucent bodies, so that a wavelength monitoring optical path of a laser wavelength monitoring apparatus is significantly shortened compared with that in the prior art, a volume of the laser wavelength monitoring apparatus is relatively small, and miniaturized packaging can be implemented, which significantly reduces packaging costs of a product. In addition, a laser wavelength monitoring apparatus that has a filter can perform transmittance power monitoring and reflected power monitoring, and monitoring precision of a wavelength offset is doubled. Therefore, the laser wavelength monitoring apparatus has higher monitoring precision compared with that in the prior art.

BRIEF DESCRIPTION OF DRAWINGS

[0023]

FIG. 1 is a schematic structural diagram of a prior laser wavelength monitoring apparatus;
FIG. 2a is a schematic structural diagram of a first implementation manner of a filter according to a first embodiment of the present invention;
FIG. 2b is a schematic structural diagram of a second implementation manner of the filter according to the first embodiment of the present invention;
FIG. 3 is a schematic flowchart of a method for producing a filter according to a fifth embodiment of the present invention;
FIG. 4 is a schematic diagram of a process of producing a filter according to an embodiment of the present invention;
DESCRIPTION OF EMBODIMENTS

[0024] To reduce a volume and costs of a laser wavelength monitoring apparatus and further improve monitoring precision, embodiments of the present invention provide a filter, a method for producing a filter, and a laser wavelength monitoring apparatus. In technical solutions of the embodiments of the present invention, a beam splitting film is disposed between first planes of two translucent bodies, so that a wavelength monitoring optical path of a laser wavelength monitoring apparatus is significantly shortened compared with that in the prior art, a volume of the laser wavelength monitoring apparatus is relatively small, and miniaturized packaging can be implemented, which makes packaging costs relatively low. In addition, a laser wavelength monitoring apparatus that has a filter can perform transmittance power monitoring and reflected power monitoring, and monitoring precision of a wavelength offset is doubled. Therefore, the laser wavelength monitoring apparatus further has higher monitoring precision compared with that in the prior art. To make the objectives, technical solutions, and advantages of the present invention more comprehensible, the following further describes the present invention in detail by listing specific embodiments.

[0025] As shown in FIG. 2a, a filter in a first embodiment of the present invention includes:

- two translucent bodies 9, where each of the translucent bodies 9 has a first plane 10, a second plane 11 that forms a wedge angle with the first plane 10, and a third plane 12 that intersects with both the first plane 10 and the second plane 11, first planes 10 of the two translucent bodies 9 are parallel to each other, and second planes 11 of the two translucent bodies 9 are parallel to each other;
- a beam splitting film 13, where surfaces of both sides are respectively combined with the first planes 10 of the two translucent bodies 9; and
- two reflective films 14, respectively combined with the second planes 11 of the two translucent bodies 9.

[0026] The translucent body 9 may include only one translucent substrate, or may include two or more translucent substrates. In the embodiment shown in FIG. 2b, in the two translucent bodies 9, one of the translucent bodies 9 includes at least two translucent substrates 16, where an antireflection coating 17 is disposed between two adjacent translucent substrates 16. By disposing the antireflection coating 17, a light loss can be reduced. A material of the translucent substrate 16 is not limited, and a material such as glass may be selected and used; a cross-section shape of the translucent substrate may be a triangle, a trapezoid, or the like.

[0027] To use a parallel interference resonance mode (including but not limited to F-P interference and G-T interference) to implement a filtering function, the first planes 10 of the two translucent bodies 9 are parallel to each other, and the second planes 11 of the two translucent bodies 9 are parallel to each other. The beam splitting film 13 has a fixed split ratio, and can divide an incident laser light by ratio, where one part is reflected, and the other part penetrates. The beam splitting film 13 may be first plated on a first plane 10 of one of the translucent bodies 9, and a first plane 10 of the other translucent body 9 is then bonded to the beam splitting film 13, so as to ensure that stable parallel interference resonance can be formed in the filter. The reflective film 14 generally includes multiple film layers in different thicknesses that are alternately distributed. These film layers may be silicon dioxide film layers, tantalum dioxide film layers, or the like. Design of a specific structure of these film layers is the prior art, and details are not described herein again.

[0028] A specific value of the wedge angle is not limited. In a filter in a second embodiment of the present invention, a wedge angle is \( 45^\circ \pm \lambda \), where \( \lambda \) is a set allowable error, for example, 1°. By selecting and using a wedge angle in this value range, design of an optical path of the filter can be relatively simple and convenient, which facilitates a layout of internal mechanical parts of a laser wavelength monitoring apparatus.

[0029] In a filter in a third embodiment of the present invention, the third planes 12 of the two translucent bodies 9 are not parallel. In a filter in a fourth embodiment of the present invention, the third planes 12 of the two translucent bodies 9 are parallel. By disposing the third planes 12 of the two translucent bodies 9 in parallel, two optical receivers of the laser wavelength monitoring apparatus can be disposed at symmetrical positions, which further facilitates design of an optical path and compactness and miniaturization of a product, and further reduces packaging costs of the product.
As shown in FIG. 3 and FIG. 4, a method for producing a filter in a fifth embodiment of the present invention includes:

Step 101: Plate a reflective film separately on second planes of two translucent bodies, and plate a beam splitting film on a first plane of one of the translucent bodies.

Step 102: Combine a first plane of the other translucent body with the beam splitting film.

In a method for producing a filter in a sixth embodiment of the present invention, step 102 is specifically combining the first plane of the other translucent body with the beam splitting film by using a bonding technology. An optical cement bonding technology is preferably used. Optical cement bonding is closely pasting together two homogeneous or heterogeneous materials after performing a series of surface processing, to form optical cement at a room temperature, and then, performing thermal treatment on the optical cement, to form permanent bonding in a case in which another binder and high pressure are not required. In an aspect of laser application, the technology not only can significantly improve thermal performance and beam quality that are of a laser, but also facilitates integration of a laser system.

As shown in FIG. 5, a laser wavelength monitoring apparatus in a seventh embodiment of the present invention includes two optical receivers 5a and 5b and the filter 15 according to any one of the foregoing embodiments.

Two reflective films 14 of the filter 15 respectively face a transmit port of a laser 7 and an incident port 8 of a transmit fiber, and two third planes 12 of the filter 15 respectively face receive ports of the two optical receivers 5a and 5b.

The optical receivers 5a and 5b may use photodiodes to detect power of a received laser light.

Referring to an eighth preferable embodiment shown in FIG. 6, the laser wavelength monitoring apparatus further includes: a collimation lens 1 located between a transmit port of a laser 7 and a reflective film 14 that is of a filter 15 and faces the transmit port of the laser 7, and a first focusing lens 2 located between an incident port 8 of a transmit fiber and a reflective film 14 that is of the filter 15 and faces the incident port 8 of the transmit fiber. The collimation lens 1 and the first focusing lens 2 may also be respectively designed in structures of the laser 7 and the incident port 8 of the transmit fiber. However, in this case, sizes of the laser 7 and the incident port 8 of the transmit fiber are relatively large, structures of the laser 7 and the incident port 8 of the transmit fiber are slightly complex, and it is also inconvenient to adjust positions of the collimation lens 1 and the first focusing lens 2.

Further referring to the preferable embodiment shown in FIG. 6, the laser wavelength monitoring apparatus further includes two second focusing lenses 6a and 6b, respectively located between two third planes 12 of the filter 15 and the receive ports that are of the optical receivers 5a and 5b and face the two third planes 12 of the filter 15. Similarly and alternatively, the second focusing lenses 6a and 6b may be respectively designed in structures of the optical receivers 5a and 5b. It should be noted that when areas of receiving surfaces of the optical receivers 5a and 5b meet a specific condition, disposing of the second focusing lenses 6a and 6b may be omitted.

As shown in FIG. 7, in a laser wavelength monitoring apparatus in a ninth embodiment of the present invention, one side of a collimation lens 1 is a plane and is combined with a reflective film 14 that is of a filter 15 and faces the side of the collimation lens 1. In this case, the laser wavelength monitoring apparatus has a relatively small packaging size, and the position of a first focusing lens 2 may be adjusted freely.

As shown in FIG. 8, in a laser wavelength monitoring apparatus in a tenth embodiment of the present invention, one side of a first focusing lens 2 is a plane and is combined with a reflective film 14 that is of a filter 15 and faces the side of the first focusing lens 2. In this case, the laser wavelength monitoring apparatus has a relatively small packaging size, and the position of the collimation lens may be adjusted freely.

As shown in FIG. 9, in a laser wavelength monitoring apparatus in an eleventh embodiment of the present invention, one side of a collimation lens 1 is a plane and is combined with a reflective film 14 that is of a filter 15 and faces the side of the collimation lens 1, and one side of a first focusing lens 2 is a plane and is combined with a reflective film 14 of the filter 15. In this case, a packaging size of the laser wavelength monitoring apparatus is the smallest compared with packaging sizes of the laser wavelength monitoring apparatuses in the ninth and the tenth embodiments, and positions of the collimation lens and the first focusing lens cannot be adjusted freely.

In the filter 15, when one of the translucent bodies 9 includes at least two translucent substrates 16, to reduce a loss of incident light, the translucent body 9 that includes at least two translucent substrates 16 are preferably designed on one side that is of a beam splitting film 13 and is close to an incident port 8 of a transmit fiber.

The embodiment shown in FIG. 6 is used as an example. A working principle of the laser wavelength monitoring apparatus is as follows: A laser light transmitted by a laser 7 becomes collimated light after passing through the collimation lens 1; the collimated light is incident into the reflective film 14 on one side of the filter 15, and the beam splitting film 13 divides a received laser light by ratio, where one part is reflected and emitted from the filter 15 to the first optical receiver 5a; the other part penetrates to the reflective film 14 on the other side of the filter 15, then, a part is reflected back to the beam splitting film 13, and the beam splitting film 13 divides a received laser light by ratio again, where a part is reflected and emitted from the filter to the second optical receiver 5b.
A beam splitting film is disposed between first planes of two translucent bodies, so that a wavelength monitoring optical path of a laser wavelength monitoring apparatus is significantly shortened compared with that in the prior art, a volume of the laser wavelength monitoring apparatus is relatively small, and miniaturized packaging can be implemented, which significantly reduces packaging costs of a product. For example, a wavelength monitoring apparatus in the prior art generally uses XMD packaging, and packaging costs are relatively high. However, a wavelength monitoring apparatus in the solutions may use TO packaging, which significantly reduces packaging costs.

It is assumed that PD1 and PD2 are respectively actual received optical powers of two optical receivers 5a and 5b, an overall reflected optical power of a filter 15 is Pf, and an overall transmittance optical power of the filter 15 is Pt. When a redshift occurs in a laser wavelength, the overall transmittance optical power of the filter 15 is Pt + ΔP, and when a blueshift occurs in the laser wavelength, the overall reflected optical power of the filter 15 is Pf - ΔP; PD1 does not vary with the laser wavelength. Therefore, a wavelength offset is:

\[ \Delta A = +\frac{2\Delta P}{Pf+Pt} \text{ (redshift), and } \Delta A = -\frac{2\Delta P}{Pf+Pt} \text{ (blueshift)} \]  

For a filter as a whole, Pf + Pt = P0, where P0 is a constant value, and does not vary with a laser wavelength. Therefore, a change status of a laser wavelength may also be defined according to the wavelength offset \( \Delta A \).

By comparing formula (2) with formula (1) in the prior art, it can be seen that the laser wavelength monitoring apparatus can perform transmittance power monitoring and reflected power monitoring, and monitoring precision of a wavelength offset is doubled. Therefore, compared with a laser wavelength monitoring apparatus in the prior art, the laser wavelength monitoring apparatus has higher monitoring precision and higher monitoring performance.

Obviously, a person skilled in the art can make various modifications and variations to the present invention without departing from the spirit and scope of the present invention. The present invention is intended to cover these modifications and variations provided that they fall within the scope of protection defined by the following claims and their equivalent technologies.

**Claims**

1. A filter, comprising:
   - two translucent bodies, wherein each of the translucent bodies has a first plane, a second plane that forms a wedge angle with the first plane, and a third plane that intersects with both the first plane and the second plane, first planes of the two translucent bodies are parallel to each other, and second planes of the two translucent bodies are parallel to each other;
   - a beam splitting film, wherein surfaces of both sides are respectively combined with the first planes of the two translucent bodies; and
   - two reflective films, respectively combined with the second planes of the two translucent bodies.

2. The filter according to claim 1, wherein the wedge angle is 45° ± \( \lambda \), and is a set allowable error.

3. The filter according to claim 1 or 2, wherein third planes of the two translucent bodies are parallel or not parallel.

4. The filter according to claim 3, wherein in the two translucent bodies, one of the translucent bodies comprises at least two translucent substrates, wherein an antireflection coating is disposed between two adjacent translucent substrates.

5. A method for producing the filter according to any one of claims 1 to 4, comprising:
   - plating a reflective film separately on second planes of two translucent bodies, and plating a beam splitting film on a first plane of one of the translucent bodies; and
   - combining a first plane of the other translucent body with the beam splitting film.

6. The production method according to claim 5, wherein the combining a first plane of the other translucent body with the beam splitting film is specifically:
   - bonding the first plane of the other translucent body to the beam splitting film.
7. A laser wavelength monitoring apparatus, comprising two optical receivers and the filter according to any one of claims 1 to 4, wherein:

    two reflective films of the filter respectively face a transmit port of a laser and a pipe orifice of an incident port of a transmit fiber, and the two third planes of the filter respectively face receive ports of the two optical receivers.

8. The laser wavelength monitoring apparatus according to claim 7, further comprising a collimation lens located between the transmit port of the laser and the reflective film that is of the filter and faces the transmit port of the laser.

9. The laser wavelength monitoring apparatus according to claim 8, wherein one side of the collimation lens is a plane and is combined with reflective film that is of the filter and faces the side of the collimation lens.

10. The laser wavelength monitoring apparatus according to any one of claims 7 to 9, further comprising a first focusing lens located between the pipe orifice of the incident port of the transmit fiber and the reflective film that is of the filter and faces the pipe orifice of the incident port of the transmit fiber.

11. The laser wavelength monitoring apparatus according to claim 10, wherein one side of the first focusing lens is a plane and is combined with the reflective film that is of the filter and faces the side of the first focusing lens.

12. The laser wavelength monitoring apparatus according to claim 7, further comprising two second focusing lenses, respectively located between the two third planes of the filter and the receive ports that are of the optical receivers and face the two third planes of the filter.

13. The laser wavelength monitoring apparatus according to claim 7, wherein in the filter, a translucent body that comprises at least two translucent substrates is located on one side that is of a beam splitting film and is close to the incident port of the transmit fiber.
Plate a reflective film separately on second planes of two translucent bodies, and plate a beam splitting film on a first plane of one of the translucent bodies.

Combine a first plane of the other translucent body with the beam splitting film.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

G02B 6/34 (2006.01)

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)

IPC: G02B 6/-; G02B 5/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, CNTXT, CNAB S, VEN, USTXT: beam splitting, light splitting, filtering, laser, split, prism, reflect+, fabry?perot, etalon, filter

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>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CN 2583691 Y (CHANGCHUN INSTITUTE OF OPTICS AND FINE MECHANICS AND PHYSICS, CHINESE ACADEMY OF SCIENCES), 29 October 2005 (29.10.2005), description, pages 5 and 6, and figure 1</td>
<td>1-13</td>
</tr>
<tr>
<td>A</td>
<td>US 2004/0109166 A1 (FIBERA INC.), 10 June 2004 (10.06.2004), the whole document</td>
<td>1-13</td>
</tr>
<tr>
<td>A</td>
<td>CN 101943772 A (HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY), 12 January 2011 (12.01.2011), the whole document</td>
<td>1-13</td>
</tr>
<tr>
<td>A</td>
<td>US 2005/0094685 A1 (COLIN, S.M. et al.), 05 May 2005 (05.05.2005), the whole document</td>
<td>1-13</td>
</tr>
<tr>
<td>A</td>
<td>CN 101726872 A (PRIMANEX (CHINA) CO., LTD.), 09 June 2010 (09.06.2010), the whole document</td>
<td>1-13</td>
</tr>
</tbody>
</table>

☐ Further documents are listed in the continuation of Box C.

* 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 application or patent but 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

“T” 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

“X” 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

“Y” 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

30 January 2014 (30.01.2014)

Date of mailing of the international search report

06 March 2014 (06.03.2014)

Name and mailing address of the ISA/CN:

State Intellectual Property Office of the P. R. China
No. 6, Xitucheng Road, Jiningqiao
Haidian District, Beijing 100088, China
Facsimile No.: (86-10) 62019451

Authorized officer

YUAN, Jiali

Telephone No.: (86-10) 82245255

Form PCT/ISA/210 (second sheet) (July 2009)
<table>
<thead>
<tr>
<th>Patent Documents referred in the Report</th>
<th>Publication Date</th>
<th>Patent Family</th>
<th>Publication Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN 2583691 Y</td>
<td>29.10.2003</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>US 2004/0109166</td>
<td>10.06.2004</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>CN 101943772 A</td>
<td>12.01.2011</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>US 2005/0094685 A1</td>
<td>05.05.2005</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>CN 101726872 A</td>
<td>09.06.2010</td>
<td>CN 101726872 B</td>
<td>19.09.2012</td>
</tr>
</tbody>
</table>

Form PCT/ISA/210 (patent family annex) (July 2009)