

SYSTEM AND METHOD FOR MEASURING EDGE COUPLING ALIGNMENT

FIELD OF THE INVENTION

The disclosures made herein relate generally to the silicon photonics and more particularly to a system and method for measuring alignment of an edge coupling device of a die in a semiconductor wafer during manufacture of a silicon photonics integrated chip (PIC) device.

BACKGROUND OF THE INVENTION

Monolithically integrated photonic circuits are mainly used as optical data links in applications including high performance computing (HPC), inter-device interconnects and optical memory extension (OME). They are also very much useful as input/output means in mobile devices to enable data exchange between the mobile devices and a host device and/or cloud servers at a rapid rate which is not possible with wireless technology or electrical cables.

Due to the compatibility with most of the existing semiconductor fabrication techniques, silicon photonic integrated circuit (PIC) devices are more advantageous in terms of cost of manufacturing and maturity of technology. However, optical input/output (I/O) entrance is an important issue in a silicon PIC device for coupling light to an optical fiber for transmission/reception. When it comes to fiber-to-chip coupling, two different optical couplings are applied, namely off-plane coupling and in-plane coupling. Grating couplers are mainly used for off-plane coupling, while edge couplers are used for in-plane coupling. Edge couplers are better than grating couplers in terms of coupling efficiency, broad bandwidth and polarization independence. However, alignment measurement of an edge coupler at wafer-level is nontrivial due to narrow trench widths ($\leq 100\mu\text{m}$ typically)

available to access the edge coupler. Accurate and reliable measurements result helps to determine a known-good-die for further packaging into final product where the packaging cost are known to be expensive.

- 5 **United States Patent No.: US 7,113,671 B2** discloses an optical coupling device for coupling light to a core of an optical waveguide device, wherein a surface of the coupling device is shaped as a lens to diffract and converge light received from a light source. A conical or funnel-shaped waveguide further converges the light to a convergence point by means of single/multiple internal reflections. This device occupies a huge space, and
10 therefore cannot be cost-effective nor efficient for optical coupling in narrow trenches.

Figure 5 shows a conventional way of alignment measurement, wherein a sharp lensed fiber (1) is inserted into the trench (3) inclined with respect to a waveguide of the edge coupler (2), such that a tip of the fiber (1) is close to an entrance of the waveguide. This
15 solution requires relatively large trench width ($>200\mu\text{m}$) to slant the sharp lens fiber at a reasonable angle ($\sim 20^\circ$). Furthermore, when used for coupling a narrow trench ($\leq 100\mu\text{m}$), the coupling loss is still very high (typically $>8\text{dB}$ per facet) due to mismatch in mode field diameter (MFD).

20 Hence, there is a need for a system and method for measuring alignment of an edge coupling device of a die in a semiconductor wafer during silicon photonic integrated chip (PIC) manufacture in a simple and cost effective manner with minimal coupling loss, while avoiding a need for high-end sophisticated arrangement.

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SUMMARY OF THE INVENTION

The present invention relates to a system for measuring alignment of an edge coupling device of a die in a semiconductor wafer. The system comprises one or more light sources, a shaped fiber selectively connectable to the light sources, a positioning device for positioning the shaped fiber with respect to the edge coupling device and a control unit
5 for controlling the light sources and the positioning device. The control unit is also capable of determining a displacement and/or a rotational angle of the shaped fiber with respect to an entrance of a waveguide in the edge coupling device. Furthermore, a viewing device is used for identifying a position of the shaped fiber with respect to the edge coupling device.

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In a preferred embodiment, the shaped fiber is configured to change a direction of light propagating through the shaped fiber, more preferably at an angle of 90° with respect to an axis of the shaped fiber. Furthermore, a light sensor is used for measuring intensity of light received at the entrance of the waveguide, the control unit automatically controls the
15 positioning device based on the measured light intensity.

The present invention also relates to a method for measuring alignment of an edge coupling device of a die in a semiconductor wafer. The method comprises the steps of: positioning a shaped fiber at a first position and a first angle with respect to an entrance
20 of a waveguide in the edge coupling device, aligning the shaped fiber with respect to the entrance of the edge coupling device (120) and measuring alignment of the edge coupling device. A position of the shaped fiber with respect to the entrance of the waveguide is continuously monitored through a viewing device. After aligning, the shaped fiber is at a second position and/or second angle with respect to the entrance of the waveguide.

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In a preferred embodiment, the aligning step includes connecting the shaped fiber to a light source for passing light rays through the shaped fiber, coarsely aligning the shaped fiber with respect to the entrance of the waveguide, replacing the light source with a laser source for passing a laser light through the shaped fiber and finely aligning the shaped fiber with respect to the entrance of the waveguide. Furthermore, the shaped fiber is configured to change a direction of light propagating through the shaped fiber, preferably at an angle of 90° with respect to an axis of the shaped fiber.

The shaped fiber is positioned at the first position and the first angle by detecting a position mark indicating a position of a trench of the edge coupling device and then inserting the shaped fiber into the trench, such that said shaped fiber is positioned at the first position and the first angle. Preferably, the position marker is formed on the die during manufacture.

In one aspect of the present invention, the coarsely aligning step includes adjusting an angle and/or a distance of the shaped fiber with respect to the entrance of the waveguide, such that a difference between a cross sectional area/width of the entrance and a cross sectional area/width of a light beam exiting the shaped fiber is within a predetermined range. Furthermore, the finely aligning step includes adjusting a position of the shaped fiber with respect to the entrance, such that an intensity of a light beam received at the entrance reaches a maximum level. The alignment of the edge coupling device is measured by determining a displacement and/or an angle of rotation undergone by the shaped fiber during the aligning step.

Since the shaped fiber can change the light direction, the shaped fiber can be easily inserted into narrow trenches, while maximizing the optical coupling efficiency.

Therefore, a need for wider trench for optimal coupling is avoided, and thus minimizing a size of the edge coupling device, which in turn increase a number of dies in a single semiconductor wafer. Furthermore, the present invention maximizes the optical coupling, and thus provides accurate measurement of alignment of the edge coupling device at
5 wafer level, which in turn helps in determining a known-good-die for further packaging into a final product and avoiding moving damaged or faulty dies into the final product.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The present invention will be fully understood from the detailed description given herein
10 below and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, wherein:

In the appended drawings:

Figure 1 shows a schematic representation of the system for measuring alignment of an edge coupling device of a die in a semiconductor wafer, in accordance with an exemplary
15 embodiment of the present invention;

Figure 2 shows a schematic representation of a shaped fiber inserted into a trench of an edge coupling device during coarse alignment, in accordance with an exemplary embodiment of the present invention;

Figure 3 shows a schematic representation of a shaped fiber inserted into a trench of an edge coupling device during fine alignment, in accordance with an exemplary
20 embodiment of the present invention;

Figure 4 shows a flow diagram of the method for fabricating the device, in accordance with the first embodiment of the present invention;

Figure 5 shows a schematic representation of a sharp lens fiber inserted into a trench of
25 an edge coupling device during alignment, in accordance with a conventional embodiment of the present invention; and

Figure 6 shows a schematic representation of a shaped fiber inserted into a slanted trench of an edge coupling device, in accordance with an exemplary embodiment of the present invention.

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DETAILED DESCRIPTION OF THE INVENTION

Detailed description of preferred embodiments of the present invention is disclosed herein. It should be understood, however, that the embodiments are merely exemplary of the present invention, which may be embodied in various forms. Therefore, the details disclosed herein are not to be interpreted as limiting, but merely as the basis for the claims and for teaching one skilled in the art of the invention. The numerical data or ranges used in the specification are not to be construed as limiting. The following detailed description of the preferred embodiments will now be described in accordance with the attached drawings, either individually or in combination.

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The present invention relates to a system and method for measuring alignment of an edge coupling device of a die in a semiconductor wafer during manufacture of a silicon photonic integrated chip (PIC) device. The present invention includes a shaped fiber configured at to change a direction of light inputted into the shaped fiber at an angle of 90° with respect to an axis of the shaped fiber. Since the shaped fiber can change the light direction at an angle of 90°, the shaped fiber can be inserted vertically into a trench in the edge coupling device, while maximizing the optical coupling with a horizontal waveguide of the edge coupling device. Therefore, a need for wider trench for optimal coupling is avoided, and thus minimizing a size of the edge coupling device, which in turn increase a number of dies in a single semiconductor wafer. Furthermore, the present invention maximizes the optical coupling, and thus provides accurate measurement of alignment of

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the edge coupling device at wafer level, which in turn helps in determining a known-good-die for further packaging into a final product and avoiding moving damaged or faulty dies into the final product.

5 Referring to the accompanying drawings, **Figure 1** shows a schematic representation of a system for measuring alignment of an edge coupling device of a die in a semiconductor wafer, in accordance with an exemplary embodiment of the present invention. The system (10) comprises one or more light sources (11), a shaped fiber (12), a positioning device (13), a control unit (14) and a viewing device (15). Furthermore, the system (10) include
10 a support means (not shown) for supporting a semiconductor wafer including multiple dies, wherein each die may include an edge coupling device (20) or an array of edge coupling devices to be tested for alignment thereof. It is to be understood that the system (10) also includes a power module (not shown) connected to a power source such as AC mains, battery and/or generator, for supplying power to the component of the system (10).

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The edge coupling device (20) includes one or more trenches (21) and one or more waveguides (22), wherein an entrance (23) of each waveguide (22) is formed on a wall of the corresponding trench (21). Preferably, the waveguides (22) are parallel to a top surface of the edge coupling device (20). Alternatively, one or more waveguides (22) may
20 be inclined with respect to the top surface of the edge coupling device (20) according to specific requirements of the silicon PIC device. However, the entrance (23) of each waveguide may be parallel or inclined to the wall of the corresponding trench (21).

The shaped fiber (12) is configured to change a direction of light propagating through the
25 shaped fiber (12). In a preferred embodiment, the shaped fiber (12) is configured to change a direction of light inputted into the shaped fiber (12) at an angle of 90° with

respect to an axis of the shaped fiber (12). Alternatively, the shaped fiber (12) may also be configured to change the light direction at an acute angle or at an obtuse angle according to specific requirement of construction of a slanted trench (21), as shown in **Figure 6**, wherein a light beam exiting the shaped fiber (12) is parallel to an axis of the waveguide (22).

Preferably, the shaped fiber (12) includes a lens such as ball lens, capable of converging light rays, wherein the lens is formed with a flat surface, which is polished to reflect any light ray incident on the flat surface. Alternatively, the flat surface is coated with a reflective coating such as silver coating, for reflecting the light rays. An angle of inclination of the flat surface with respect to the axis of the shaped fiber determines the angle of change in direction of the propagating light. Preferably, the flat surface is angled with respect to the axis of the shaped fiber (12), such that when light rays propagating therethrough are incident on the flat surface, the light rays are reflected at 90° with respect to the axis of the shaped fiber (12) and are converged by the lens as they exit the shaped fiber (12).

The light sources (11) include a laser source and a visible light source selectively connectable to the shaped fiber (12) by means of any conventional coupling device e.g. optical switch. Preferably, the visible light source is connected to the shaped fiber (12) while coarsely aligning the shaped fiber (12) with respect to the entrance (23) of the waveguide, whereas the laser source is connected to the shaped fiber (12) while finely aligning the shaped fiber (12) with respect to the entrance (23).

The viewing device (15) is used for identifying a position of the shaped fiber (12) with respect to the edge coupling device (20). Furthermore, the viewing device (15) is used for

detecting a position marker indicating a position of the trench (21) of the edge coupling device (20) in the die. In a preferred embodiment, the die is formed with the position marker during manufacture by means of etching or any other conventional means of marking. Before initiating coarse alignment, the position marker is detected using the
5 viewing device (15) and then the shaped fiber is inserted into the trench (21), such that the shaped fiber (12) is positioned at a first position and a first angle with respect to the position marker.

The viewing device (15) is an optical viewing device such as microscope, camera-display
10 combination or any other device capable of magnifying the trench (21) to be visible to a manual operator operating the positioning device (13). During coarse alignment, the shaped fiber (12) is inclined with respect to the waveguide (22) and inserted into the trench (21), as shown in **Figure 2**. Furthermore, an angle and/or distance of the shaped fiber (12) with respect to the entrance (23) is adjusted using the positioning device (13),
15 such that a difference between a width of a light beam exiting the shaped fiber (12) and a width of the entrance (23) is within a predetermined range. Preferably, the difference is within a range of -5 to 5 microns. Furthermore, during the coarse alignment, the shaped fiber (12) is moved and/or rotated with respect to the edge coupling device (20), such that the light beam exiting the shaped fiber (12) and the waveguide (22) are made coaxial to
20 one another.

In a preferred embodiment, the positioning device (13) is one or more robotic arms or any other mechanical mechanism capable of moving and/or rotating the shaped fiber (12) with respect to the edge coupling device (20), according to one or more commands received
25 from the manual operator through the control unit (14). More preferably, the control unit (14) includes an input device such as keyboard, joystick, touchscreen, etc., for inputting

the commands by the operator. For example, the operator views through the viewing device (15) and inputs the commands accordingly for positioning the shaped fiber (12).

In an alternate embodiment, the system (10) may operate in an automated mode, wherein
5 the control unit (14) includes one or more microcontrollers configured to automatically control the positioning device (13) based on inputs from one or more sensors (not shown). For example, the control unit (14) may receiving inputs from an imaging sensor capturing still or video images of the entrance (23) and the light beam incident on the entrance (23) to calculate the width difference and control the positioning device (13) accordingly.
10 Furthermore, the control unit (14) is capable of controlling the light sources (11). Optionally, the light sources (11) include a single laser source controlled by the control unit (14) for the coarse alignment as well as for the fine alignment.

After completing the coarse alignment, the positioning device (13) is controlled manually
15 or automatically for finely aligning the shaped fiber (12) with respect to the entrance (23). Irrespective of the manual or automatic mode of operation, the laser source is optically coupled to the shaped fiber (12). The system (10) includes a light sensor (24, shown in **Figure 3**) such as photodiode, coupled to the waveguide (22) for measuring intensity of light received at the entrance (23) of the waveguide (22), wherein the measured light
20 intensity is displayed using a display device such as an LCD screen.

Based on the measured light intensity, the positioning device (13) is controlled for finely aligning the shaped fiber (12) until the measured light intensity reaches a maximum level. Alternatively, the control unit (14) receives the measured light intensity for automatically
25 controlling the positioning device (13) for fine alignment of the shape fiber (12) until the measured light intensity reaches the maximum level.

After completing the fine alignment, the control unit (14) marks a position and angle of the shaped fiber (12) with respect to the position marker as a second position and a second angle. Furthermore, the control unit (14) determines a displacement and/or a rotational angle of the shaped fiber (12) with respect to the entrance (23) of the waveguide (22) from the difference between the first position and first angle and the second position and second angle. Upon completing the fine alignment, the control unit (14) determines the displacement and/or angle of rotation between the first position and first angle and the second position and second angle as a measurement of the alignment of the edge coupling device (20). This alignment measurement is stored and utilized for easy and quick identification of an alignment of the edge coupling devices in each die with respect to the position marker, during further processing of the die, for example testing of the edge coupling devices.

Since the present invention includes the shaped fiber (12) capable of changing direction of inputted light, it is possible to insert the shaped fiber into narrow trenches ($\leq 100\mu\text{m}$) for alignment measurement of the edge coupling device at wafer-level in a simple and cost effective manner without compromising on the coupling efficiency and without a need for high-end sophisticated arrangements. Therefore, a need for wider trench for optimal coupling is avoided, and thus minimizing a size of the edge coupling device, which in turn increases a number of dies in a single semiconductor wafer and minimizes the cost of manufacture. Furthermore, the present invention maximizes the optical coupling as the light beam is made to enter the waveguide in parallel, and thus provides accurate measurement of alignment of the edge coupling device at wafer level, which in turn helps in determining a known-good-die for further packaging into a final product and avoiding moving damaged or faulty dies into the final product.

Figure 4 shows a flow diagram of the method for measuring alignment of an edge coupling device of a die in a semiconductor wafer, in accordance with an exemplary embodiment of the present invention. The method (100) comprises the steps of: (a)

5 positioning at least one shaped fiber at a first position with respect to an entrance of a waveguide in the edge coupling device (110), aligning the shaped fiber with respect to the entrance (120) and measuring alignment of the edge coupling device (130). Preferably, a position of the shaped fiber with respect the entrance is continuously monitored through a viewing device during the aligning step.

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In a preferred embodiment, the aligning step includes a coarse aligning step and a fine aligning step. During the coarse aligning step, the shaped fiber is connected to a visible light source for passing light rays through the shaped fiber and then coarsely aligning the shaped fiber with respect to the entrance of the waveguide. During the fine aligning step,

15 the visible light source is replaced with a laser source for passing laser light through the shaped fiber and the shaped fiber is finely aligned with respect to the entrance of the waveguide.

Before initiating the coarse aligning step, the shaped fiber is positioned with respect to

20 the entrance of the waveguide by detecting a position marker formed on a surface of the die including the edge coupling device using a viewing device and then inserting the shaped fiber into a trench, such that the shaped fiber is at a first position and a first angle with respect to the position marker. The first position and the first angle are determined by a control unit used for controlling a positioning device that is capable of moving and/or

25 rotating the shaped fiber with respect to the edge coupling device.

The shaped fiber is configured to change a direction of light propagating through the shaped fiber. In a preferred embodiment, the shaped fiber is configured at to change a direction of light inputted into the shaped fiber at an angle of 90° with respect to an axis of the shaped fiber. Alternatively, the shaped fiber may also be configured to change the
5 light direction at an acute angle or at an obtuse angle according to specific requirement of construction of the trench, as shown in **Figure 6**.

Preferably, the shaped fiber includes a lens such as ball lens, capable of converging light rays, wherein the lens is formed with a flat surface, which is polished to reflect any light
10 ray incident on the flat surface. Alternatively, the flat surface is coated with a reflective coating such as silver coating, for reflecting the light rays. An angle of inclination of the flat surface with respect to the axis of the shaped fiber determines the angle of change in direction of the propagating light. Preferably, the flat surface is angled with respect to the axis of the shaped fiber, such that when light rays propagating therethrough are incident
15 on the flat surface, the light rays are reflected at 90° with respect to the axis of the shaped fiber and are converged by the lens as they exit the shaped fiber.

After the shaped fiber is positioned at the first position and the first angle, the coarse aligning step is initiated, wherein the positioning device is operated for adjusting an angle
20 and/or a distance of the shaped fiber with respect to the entrance of the edge coupling device. The angle and/or the distance of the shaped fiber is adjusted until a difference between a width of the entrance of the waveguide and a width of a light beam exiting the shaped fiber is within a predetermined range, preferably -5 to $+5\ \mu\text{m}$. Furthermore, the shaped fiber is coarsely aligned to make the light beam coaxial to the waveguide.

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After completing the coarse alignment, the positioning device is controlled manually or automatically for finely aligning the shaped fiber with respect to the entrance. The laser source is optically coupled to the shaped fiber to pass a laser light beam to the waveguide and intensity of light received at the entrance of the waveguide is measured. Preferably, 5 light sensor such as photodiode, is coupled to the waveguide for measuring the light intensity and the measured light intensity is displayed using a display device such as an LCD screen. Based on the measured light intensity, the positioning device is controlled for finely aligning the shaped fiber until the measured light intensity reaches a maximum level. Alternatively, the control unit receives the measured light intensity for 10 automatically controlling the positioning device for fine alignment of the shape fiber until the measured light intensity reaches the maximum level.

After completing the fine alignment, a position and angle of the shaped fiber with respect to the position marker are identified by the control unit as a second position and a second 15 angle. Furthermore, a displacement and/or a rotational angle of the shaped fiber with respect to the entrance of the waveguide is determined by the control unit by calculating a difference between the first position and first angle and the second position and second angle, respectively. Upon completing the fine alignment, the displacement and/or angle of rotation undergone by the shaped fiber from the first position and the first angle to the 20 second position and the second angle is determined as a measurement of the alignment of the edge coupling device with respect to the position marker. This alignment measurement is stored and utilized for easy and quick identification of an alignment of the edge coupling devices in each die with respect to the position marker, during further processing of the die, for example testing of the edge coupling devices.

Since the present invention includes the shaped fiber capable of changing direction of inputted light, it is possible to insert the shaped fiber into narrow trenches ($\leq 100\mu\text{m}$) for alignment measurement of the edge coupling device at wafer-level in a simple and cost effective manner without compromising on the coupling efficiency and without a need for high-end sophisticated arrangements. Therefore, a need for wider trench for optimal coupling is avoided, and thus minimizing a size of the edge coupling device, which in turn increases a number of dies in a single semiconductor wafer and minimizes the cost of manufacture. Furthermore, the present invention maximizes the optical coupling as the light beam is made to enter the waveguide in parallel, and thus provides accurate measurement of alignment of the edge coupling device at wafer level, which in turn helps in determining a known-good-die for further packaging into a final product and avoiding moving damaged or faulty dies into the final product.

Even though, in the above embodiments, the present invention is applied for measuring alignment of the edge coupling device that is formed as a passive device receiving light signals, it is to be understood that the present invention may also be applied for measuring alignment of an active device such as edge emitting diode, wherein a direction of light propagation is opposite to the light direction as described in the above embodiments.

The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a", "an" and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises", "comprising", "including" and "having" are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or

addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

The method steps, processes and operations described herein are not to be construed as
5 necessarily requiring their performance in the particular order discussed or illustrated,
unless specifically identified as an order of performance. It is also to be understood that
additional or alternative steps may be employed. The use of the expression “at least” or
“at least one” suggests the use of one or more elements, as the use may be in one of the
embodiments to achieve one or more of the desired objects or results.

CLAIMS.

1. A system (10) for measuring alignment of an edge coupling device (20) of a die in a semiconductor wafer, comprising:
 - 5 (a) one or more light sources (11), wherein at least one light source emits laser light;
 - (b) at least one shaped fiber (12) selectively connectable to said light sources (11);
 - (c) at least one positioning device (13) for positioning said shaped fiber (12) with respect to said edge coupling device (20)
 - 10 (d) a control unit (14) for controlling said light sources (11) and said positioning device (13) and for determining at least one of a displacement and a rotational angle of said shaped fiber (12) with respect to an entrance (23) of a waveguide (22) in said edge coupling device (20);
 - (e) at least one viewing device (15) for viewing a position of said shaped fiber (12) with respect to said edge coupling device (20),
 - 15 characterized in that said shaped fiber (12) is configured to change a direction of light propagating through said shaped fiber (12).
2. The system (10) of claim 1, wherein said shaped fiber (12) is configured to change the direction of light at an angle of 90° with respect to an axis of said shaped fiber (12).
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3. The system (10) of claim 1, further includes at least one light sensor for measuring intensity of light received at said entrance (23) of said waveguide (22).
4. The system (10) of claim 3, wherein said control unit automatically controls said positioning device (13) based on light intensity measured by said light sensor.
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5. A method (100) for measuring alignment of an edge coupling device of a die in a semiconductor wafer, comprising:
 - 30 (a) positioning at least one shaped fiber at a first position and a first angle with respect to an entrance of a waveguide in said edge coupling device (110);
 - (b) aligning said shaped fiber with respect to said entrance (120), wherein a position of said shaped fiber with respect to said entrance is continuously monitored through at least one viewing device and said shaped fiber is at a second position

and/or second angle with respect to said entrance of said waveguide after aligning;
and

(c) measuring alignment of said edge coupling device (130),
characterized in that said step of aligning includes:

- 5 - connecting said shaped fiber to a light source for passing light rays through said shaped fiber;
- coarsely aligning said shaped fiber with respect to said entrance;
- replacing said light source with a laser source for passing a laser light through said shaped fiber; and
- 10 - finely aligning said shaped fiber with respect to said entrance,
 wherein said shaped fiber is configured to change a direction of light propagating through said shaped fiber.

6. The method (100) of claim 5, wherein said step of positioning said shaped fiber
15 includes:

- detecting a position marker indicating a position of a trench of said edge coupling device, wherein said position marker is formed on said die during manufacture; and
- inserting said shaped fiber into a trench of said edge coupling device, such that said shaped fiber is positioned at said first position and said first angle.

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7. The method (100) of claim 5, wherein said step of coarsely aligning includes:

- adjusting at least one of an angle or a distance of said shaped fiber with respect to said entrance of said waveguide, such that a difference between a width of said entrance and a width of a light beam exiting said shaped fiber is within a
25 predetermined range.

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8. The method (100) of claim 5, wherein said step of finely aligning includes:

- adjusting a position of said shaped fiber with respect to said entrance, such that an intensity of a light beam received at said entrance reaches a maximum level.

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9. The method (100) of claim 5, wherein said step of measuring alignment includes:

- determining a displacement and/or an angle of rotation undergone by said shaped fiber during said step of aligning.

10. The method (100) of claim 5, wherein said shaped fiber is configured at to change the
5 direction of light at an angle of 90° with respect to an axis of said shaped fiber.