

[0065] Although the foregoing invention has been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications can be practiced within the scope of the appended claims. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and
5 the invention is not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.

~~What is claimed is:~~

CLAIMS

1. An end effector having a dual sensor for detecting presence of a wafer, comprising:
 - an arm having a first end and a second end, the first end being connected to a pivoting joint, a first point and a second point being defined at the second end;
 - a light emitter operable to generate a light signal; and
 - a light sensor for detecting the light signal after the light signal is routed around the arm through a single light path, the single light path including a first segment and a second segment, the first segment being defined between the first point and the second point, and the second segment intersecting a wafer when loaded on the end effector;

wherein a mapping function of a control module identifies presence of the wafer between the first point and the second point when the wafer is not loaded on the end effector and the wafer intersects the first segment blocking the light signal from reaching the light sensor;

wherein a load function of the control module identifies presence of the wafer between the first end and the second end when the wafer is loaded on the end effector and the wafer intersects the second segment blocking the light signal from reaching the light sensor, wherein the control module determines if an interruption in the light signal corresponds to an interruption in the first segment or in the second segment, wherein the control module determines that the interruption of the single light path is in the first segment when the end effector is performing the mapping function, and the control module determines that the interruption of the single light path is in the second segment when the end effector is performing the load function.
2. The end effector of claim 1, wherein the first segment is substantially horizontal and allows the detection of the wafer when the wafer is in front of the end effector.

3. The end effector of claim 1, wherein the second segment has a vertical component and intersects a horizontal plane at an angle bigger than 0.
4. The end effector of claim 3, wherein the second segment connects a point in the end effector above a loaded wafer and a point in the end effector below a loaded wafer.
5. The end effector of claim 1, further including:
a vacuum sensor that senses when the wafer is loaded in the end effector.
6. The end effector of claim 5, wherein the control module determines that a wafer is properly loaded when the load function and the vacuum sensor indicate proper loading of the wafer, and the control module determines that a wafer is improperly loaded when one of the load function or the vacuum sensor indicates proper loading of the wafer and one of the load function or the vacuum sensor indicates improper loading of the wafer.
7. The end effector of claim 6, wherein the end effector moves at regular speed when the wafer is properly loaded.
8. The end effector of claim 6, wherein the end effector moves at slow speed when the wafer is improperly loaded.
9. The end effector of claim 1, wherein exceeding a threshold value in an amount of interference with the single light path determines that an interruption of the single light path has taken place.

10. A method for detecting presence of a wafer by an end effector, comprising:
- generating a light signal by a light emitter;
 - routing the light signal through a single light path around an arm of an end effector, the single light path ending at a light sensor for detecting presence of the light signal, the arm having a first end and a second end, wherein a first point and a second point are defined at the second end, the single light path including a first segment and a second segment, the first segment being defined between the first point and the second point, and the second segment intersecting a wafer when loaded on the end effector;
 - detecting interference with the light signal in a mapping function of a control module when the wafer is between the first point and the second point and the wafer is not loaded on the end effector and the wafer intersects the first segment blocking the light signal from reaching the light sensor;
 - detecting interference with the light signal in a load function of the control module when the wafer is between the first end and the second end and the wafer is loaded on the end effector and the wafer intersects the second segment blocking the light signal from reaching the light sensor; and
 - determining by a control module if an interruption in the single light path corresponds to an interference with the light signal in the mapping function or in the load function, wherein the mapping function determines that a wafer is not properly situated in a horizontal position before loading the wafer in the end effector when the end effector is moving substantially vertically and the mapping function detects interference with the light signal for an amount of time longer than a time corresponding to a sensor properly placed in a horizontal position.
11. The method as recited in claim 10, wherein the arm of the end effector further includes a second sensor selected from a group consisting of a touch sensor, a vacuum sensor, a mechanical sensor, an active grip sensor, a proximity sensor and an inductive sensor.

12. The method as recited in claim 11, further including:
combining information from two or more sensors to determine if the wafer is properly loaded in the end effector.
13. The method as recited in claim 10, wherein the light emitter is a light emitting diode (LED).
14. The method as recited in claim 10, wherein the light emitter is a laser.
15. The method as recited in claim 10, wherein the mapping function is used to determine presence of the wafer before loading the wafer in the end effector.
16. A computer program embedded in a non-transitory computer-readable storage medium, when executed by one or more processors, for detecting presence of a wafer by an end effector, the computer program comprising:
program instructions for generating a light signal by a light emitter;
program instructions for routing the light signal through a single light path around an arm of an end effector, the single light path ending at a light sensor for detecting presence of the light signal, the arm having a first end and a second end, wherein a first point and a second point are defined at the second end, the single light path including a first segment and a second segment, the first segment being defined between the first point and the second point, and the second segment intersecting a wafer when loaded on the end effector;
program instructions for detecting interference with the light signal in a mapping function of a control module when the wafer is between the first point and the second point and the wafer is not loaded on the end effector and the wafer intersects the first segment blocking the light signal from reaching the light sensor;

program instructions for detecting interference with the light signal in a load function of the control module when the wafer is between the first end and the second end and the wafer is loaded on the end effector and the wafer intersects the second segment blocking the light signal from reaching the light sensor; and

program instructions for determining by a control module if an interruption in the single light path corresponds to an interference with the light signal in the mapping function or in the load function, wherein the mapping function determines that a wafer is not properly situated in a horizontal position before loading the wafer in the end effector when the end effector is moving substantially vertically and the mapping function detects interference with the light signal for an amount of time longer than a time corresponding to a sensor properly placed in a horizontal position.

17. The computer program as recited in claim 16, wherein the single light path includes one or more focus lenses.

18. The computer program as recited in claim 16, wherein the single light path includes an optical amplifier.

CLAIMS

1. An end effector having a dual sensor for detecting presence of a wafer, comprising:

an arm having a first end and a second end, the first end being connected to a pivoting joint, a first point and a second point being defined at the second end, a light signal being routed around the arm through a single light path;

a mapping sensor for identifying presence of the wafer between the first point and the second point when the wafer is not loaded on the end effector, the mapping sensor being defined by a first segment in the single light path such that the wafer intersects the first segment and interferes with the single light path when the wafer is situated between the first point and the second point and not loaded on the end effector; and

a load sensor for identifying presence of the wafer between the first end and the second end when the wafer is loaded on the end effector, the load sensor being defined by a second segment in the single light path such that the wafer intersects the second segment and interferes with the single light path when the wafer is loaded,

wherein a control module determines if an interruption in the single light path corresponds to an interruption of the single light path in the first segment or in the second segment.

2. The end effector of claim 1, wherein the control module determines that the interruption of the single light path is in the first segment when the end effector is performing a mapping function, and the control module determines that the

interruption of the single light path is in the second segment when the end effector is performing a load function.

3. The end effector of claim 1, wherein the first segment is substantially horizontal and allows the detection of the wafer when the wafer is in front of the end effector.

4. The end effector of claim 1, wherein the second segment has a vertical component and intersects a horizontal plane at an angle bigger than 0.

5. The end effector of claim 4, wherein the second segment connects a point in the end effector above a loaded wafer and a point in the end effector below a loaded wafer.

6. The end effector of claim 1, further including:
a vacuum sensor that senses when the wafer is loaded in the end effector.

7. The end effector of claim 6, wherein the control module determines that a wafer is properly loaded when the load sensor and the vacuum sensor indicate proper loading of the wafer, and the control module determines that a wafer is improperly loaded when one of the load sensor and the vacuum sensor indicates proper loading of the wafer and the other sensor indicates improper loading of the wafer.

8. The end effector of claim 7, wherein the end effector moves at regular speed when the wafer is properly loaded.

9. The end effector of claim 7, wherein the end effector moves at slow speed when the wafer is improperly loaded.

10. The end effector of claim 1, wherein exceeding a threshold value in an amount of interference with the single light path determines that an interruption of the single light path has taken place.

11. A method for detecting presence of a wafer by an end effector, comprising:

routing a light signal through a single light path around an arm of an end effector, the arm having a first end and a second end, wherein a first point and a second point are defined at the second end;

detecting interference with the light signal in a mapping sensor when the wafer is between the first point and the second point and the wafer is not loaded on the end effector, the mapping sensor being defined by a first segment in the single light path such that the wafer intersects the first segment and interferes with the single light path when the wafer is situated between the first point and the second point and not loaded on the end effector;

detecting interference with the light signal in a load sensor when the wafer is between the first end and the second end and the wafer is loaded on the end effector, the load sensor being defined by a second segment in the single light path such that

the wafer intersects the second segment and interferes with the single light path when the wafer is loaded; and

determining by a control module if an interruption in the single light path corresponds to an interference with the light signal in the mapping sensor or in the load sensor.

12. The method as recited in claim 11, wherein the arm of the end effector further includes a second sensor selected from a group consisting of a touch sensor, a vacuum sensor, a mechanical sensor, an active grip sensor, a proximity sensor and an inductive sensor.

13. The method as recited in claim 12, further including:
combining information from two or more sensors to determine if the wafer is properly loaded in the end effector.

14. The method as recited in claim 11, wherein the light signal is created by a light emitting diode (LED).

15. The method as recited in claim 11, wherein the light signal is created by a laser.

16. The method as recited in claim 11, wherein the mapping sensor is used to determine presence of the wafer before loading the wafer in the end effector.

17. The method as recited in claim 16, wherein the mapping sensor determines that a wafer is not properly situated in a horizontal position when the end effector is moving substantially vertically and the mapping sensor detects interference with the light signal for an amount of time longer than a time corresponding to a sensor properly placed in a horizontal position.

18. A computer program embedded in a non-transitory computer-readable storage medium, when executed by one or more processors, for detecting presence of a wafer by an end effector, the computer program comprising:

program instructions for routing a light signal through a single light path around an arm of an end effector, the arm having a first end and a second end, wherein a first point and a second point are defined at the second end;

program instructions for detecting interference with the light signal in a mapping sensor when the wafer is between the first point and the second point and the wafer is not loaded on the end effector, the mapping sensor being defined by a first segment in the single light path such that the wafer intersects the first segment and interferes with the single light path when the wafer is situated between the first point and the second point and not loaded on the end effector;

program instructions for detecting interference with the light signal in a load sensor when the wafer is between the first end and the second end and the wafer is loaded on the end effector, the load sensor being defined by a second segment in the single light path such that the wafer intersects the second segment and interferes with the single light path when the wafer is loaded; and

program instructions for determining by a control module if an interruption in the single light path corresponds to an interference with the light signal in the mapping sensor or in the load sensor.

19. The computer program as recited in claim 18, wherein the single light path includes one or more focus lenses.

20. The computer program as recited in claim 18, wherein the single light path includes an optical amplifier.