Claims

1. A method for automatic wafer centering, comprising:

having a wafer positioned on a wafer handling component of a robot;

operating the robot to move the wafer handling component so that the wafer is moved through an array of sensors, each sensor within the array of sensors configured to detect and signal when an edge of the wafer passes by the sensor;

determining a number (N) of detected wafer edge locations, each detected wafer edge location defined by a set of coordinates (x, y) in a coordinate system of the wafer handling component at which any sensor of the array of sensors detects the edge of the wafer as the wafer is moved through the array of sensors;

for each unique set of (N-1) of the number (N) of detected wafer edge locations, determining an estimated wafer offset that minimizes a performance index value, the estimated wafer offset defined as a vector extending from a center of the coordinate system of the wafer handling component to an estimated center location of the wafer, each unique set of (N-1) of the number (N) of detected wafer edge locations having a corresponding estimated wafer offset and a corresponding performance index value;

identifying a final wafer offset as the estimated wafer offset corresponding to the unique set of (N-1) of the number (N) of detected wafer edge locations that has a smallest corresponding performance index value; and

using the final wafer offset to center the wafer at a target station.

2. The method as recited in claim 1, wherein the array of sensors includes at least three sensors.

3. The method as recited in claim 1, wherein the array of sensors includes at least one sensor positioned to pass over a first half of the wafer relative to a direction of travel of a center of the wafer as the wafer is moved through the array of sensors, and wherein the array of sensors includes at least one sensor positioned to pass over a second half of the wafer relative to the direction of travel of the center of the wafer as the wafer is moved through the array of sensors.

4. The method as recited in claim 1, wherein each sensor in the array of sensors is a light beam sensor.

5. The method as recited in claim 4, wherein the light beam sensor is configured to transmit a signal indicating detection of the edge of the wafer when a light beam of the light beam sensor is broken by the wafer, and wherein the light beam sensor is configured to transmit

a signal indicating detection of the edge of the wafer when a broken light beam of the light beam sensor is reformed.

6. The method as recited in claim 1, wherein the estimated wafer offset for a given unique set of (N-1) of the number (N) of detected wafer edge locations corresponds to a center of a circle that is best fit to the given unique set of (N-1) of the number (N) of detected wafer edge locations within the coordinate system of the wafer handling component.

7. The method as recited in claim 6, wherein the performance index value is defined as a square of a difference between an estimated wafer radius and a known nominal radius of the wafer at an i-th detected wafer edge location of the wafer summed over the given unique set of (N-1) of the number (N) of detected wafer edge locations, wherein a minimized performance index value and an associated estimated wafer center correspond to the circle that is best fit to the given unique set of (N-1) of the number (N) of detected wafer edge locations within the coordinate system of the wafer handling component.

8. The method as recited in claim 1, wherein the unique set of (N-1) of the number (N) of detected wafer edge locations that has the smallest corresponding performance index value excludes one of the number (N) of detected wafer edge locations at a fiducial of the wafer.

9. A system for automatic wafer centering, comprising:

an array of sensors, each sensor within the array of sensors configured to detect when an edge of a wafer passes by the sensor; and

a controller configured to receive data indicating a position of a wafer handling component of a robot as the wafer handling component is moved with a wafer held on the wafer handling component, the controller configured to receive signals from the array of sensors as the wafer is moved through the array of sensors, the signals indicating when the edge of the wafer passes by a particular sensor of the array of sensors,

the controller configured to determine a number (N) of detected wafer edge locations, each detected wafer edge location defined by a set of coordinates (x, y) in a coordinate system of the wafer handling component at which any sensor of the array of sensors detects the edge of the wafer,

the controller configured to determine an estimated wafer offset that minimizes a performance index value for each unique set of (N-1) of the number (N) of detected wafer edge locations, the estimated wafer offset defined as a vector extending from a center of the coordinate system of the wafer handling component to an estimated center location of the wafer, each unique set of (N-1) of the number (N) of detected wafer edge locations having a corresponding estimated wafer offset and a corresponding performance index value,

the controller configured to identify a final wafer offset as the estimated wafer offset corresponding to the unique set of (N-1) of the number (N) of detected wafer edge locations that has a smallest corresponding performance index value,

the controller configured to use the final wafer offset to direct the robot to center the wafer at a target station.

10. The system as recited in claim 9, wherein the array of sensors includes at least three sensors.

11. The system as recited in claim 9, wherein the array of sensors includes at least one sensor positioned to pass over a first half of the wafer relative to a direction of travel of a center of the wafer as the wafer is moved through the array of sensors, and wherein the array of sensors includes at least one sensor positioned to pass over a second half of the wafer relative to the direction of travel of the center of the wafer as the wafer is moved through the array of sensors.

12. The system as recited in claim 9, wherein each sensor in the array of sensors is a light beam sensor.

13. The system as recited in claim 12, wherein the light beam sensor is configured to transmit a signal indicating detection of the edge of the wafer when a light beam of the light beam sensor is broken by the wafer, and wherein the light beam sensor is configured to transmit a signal indicating detection of the edge of the wafer when a broken light beam of the light beam sensor is reformed.

14. The system as recited in claim 9, wherein the estimated wafer offset for a given unique set of (N-1) of the number (N) of detected wafer edge locations corresponds to a center of a circle that is best fit to the given unique set of (N-1) of the number (N) of detected wafer edge locations within the coordinate system of the wafer handling component.

15. The system as recited in claim 14, wherein the performance index value is defined as a square of a difference between an estimated wafer radius and a known nominal radius of the wafer at an i-th detected wafer edge location of the wafer summed over the given unique set of (N-1) of the number (N) of detected wafer edge locations, wherein a minimized performance index value and an associated estimated wafer center correspond to the circle that is best fit to the given unique set of (N-1) of the number (N) of detected wafer edge locations within the coordinate system of the wafer handling component.

16. The system as recited in claim 9, wherein the unique set of (N-1) of the number (N) of detected wafer edge locations that has the smallest corresponding performance index value excludes one of the number (N) of detected wafer edge locations at a fiducial of the wafer.

17. A method for automatic wafer centering, comprising:

acquiring a number (N) of detected wafer edge locations, each detected wafer edge location defined by a set of coordinates (x, y) in a coordinate system of a wafer handling component;

determining a minimized performance index value for each unique set of (N-1) of the number (N) of detected wafer edge locations, wherein the minimized performance index value has an associated estimated wafer offset that corresponds to a center of a circle that is best fit to a corresponding unique set of (N-1) of the number (N) of detected wafer edge locations within the coordinate system of the wafer handling component;

determining a smallest minimized performance index value for the number (N) of detected wafer edge locations; and

using the smallest minimized performance index value and its associated wafer offset to center the wafer at a target station.

18. The method as recited in claim 17, wherein the number (N) of detected wafer edge locations are acquired by passing the wafer through an array of light beam sensors that includes at least three sensors.

19. The method as recited in claim 17, wherein the performance index value is defined as a square of a difference between an estimated wafer radius and a known nominal radius of the wafer at an i-th detected wafer edge location of the wafer summed over a given unique set of (N-1) of the number (N) of detected wafer edge locations.

20. The method as recited in claim 17, wherein a particular unique set of (N-1) of the number (N) of detected wafer edge locations that has the smallest minimized performance index value excludes one of the number (N) of detected wafer edge locations at a fiducial of the wafer.