SYSTEM AND METHOD FOR BLADE REFURBISHMENT

FIELD OF INVENTION

The invention relates to means to enable the reuse of used products. More particularly, a system and a method for blade refurbishment that enables used dicing blades to be refurbished for their reuse in semiconductor wafer dicing operations.

BACKGROUND OF THE INVENTION

Conventionally, in the semiconductor industry, the dicing operation of semiconductors involves cutting a semiconductor wafer into singulated packages, which is performed by using a dicing machine having a dicing blade. After performing the dicing operation repeatedly, the dicing blade shall become worn and its blade exposure becomes insufficient or diminished. With this, the dicing blade shall be typically disposed and it is replaced with a new dicing blade. However, this will cause an increase in waste, and furthermore, the disposed dicing blade may have portions that remain utilised.

There are a few disclosed technologies over the prior art relating to means for blade refurbishing. Among them include the Japanese Patent Application JP2006312217A, which discloses a blade conditioning system and method that involves an annular frame, which is mounted with a turning stone and a dressing stone, for performing truing operations and dressing operations on a blade so that the blade may be conditioned for its further use in a cutting process.

However, the aforementioned prior art merely teaches means for conditioning a blade without refurbishing it for its parameters to be restored to its prior, or original, specifications. Accordingly, it is desirable to have a system and a method for blade refurbishment like so.

SUMMARY OF INVENTION

The main objective of the invention is to provide a system and method for blade refurbishment of one or more blades, with these blades being dicing blades. More specifically, the invention aims to extend an exposure length of a used blade to enhance its cutting efficiency and effectiveness. To achieve this objective, the invention provides one or more units configured to modify one or more blades by either removing at least one area from a hub of the blade, removing at least one area from a cutting edge of the blade. This is so that the blade to be restored to a prior or original specification or a modified specification. Advantageously, this shall allow used blades to be reused for their intended processes in which they may have optimal cutting performance and extended blade longetivity. This is so that used dicing blades are refurbished for their reuse in semiconductor wafer dicing processes.

The present invention intends to provide a system for blade refurbishment of one or more blades, comprising one or more modification units, which are provided with the blades. The modification units are configured to either remove material from a hub of each blade, remove material from at least one cutting edge of each blade, or both, for at least one parameter of each blade, which at least includes its blade exposure, to be restored to a prior or original specification, or to be of a modified specification.

Preferably, the modification unit is further configured to further control an outer diameter size of each blade, or a combination thereof.

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Preferably, the system further comprises a polishing unit that is provided with the blades, the polishing unit configured to either polish each blade to expose its abrasion-resistant material, fine-tune a thickness of each blade, remove scratches from each

blade, or a combination thereof.

Preferably, the system further comprises a dressing unit that is provided with the blades, the dressing unit configured to either dress each blade to further expose its abrasion-resistant material, remove blade loading, or a combination thereof.

Preferably, the system further comprises a cleaning unit that is provided with the blades, the cleaning unit configured to clean each blade.

Preferably, the system further comprises a packing unit that is provided with the blades, the packing unit configured to pack the blades into one or more packages.

Preferably, the system further comprises a first inspection unit that is provided with the blades, the first inspection unit configured to inspect a blade condition of each blade.

Preferably, the system further comprises a second inspection unit that is provided with the blades, the second inspection unit configured to inspect a blade profile of each blade.

The present invention further intends to provide a method for blade refurbishment of one or more blades, comprising the step of providing the blades to one or more modification units. The modification units are configured to either remove material from a hub of each blade, remove material from at least one cutting edge of each blade, or both, for at least one parameter of each blade, which at least includes its blade exposure, to be restored to a prior or original specification, or to be of a modified specification.

The present invention also intends to provide a refurbished blade, wherein the blade has material removed from its hub removed, material removed from at least one of its

cutting edge, or both, by one or more modification units (103, 104), for at least one parameters of the blade, which at least includes its blade exposure, to be restored to a prior or original specification, or to be of a modified specification.

One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments described herein are not intended as limitations on the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

To facilitate an understanding of the invention, there are illustrated in the accompanying drawings the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

FIG. 1 is a simplified schematic diagram of the system for blade refurbishment as provided by the present invention.

FIG. 2 is an example flow chart illustrating the method for blade refurbishment as provided by the present invention.

FIG. 3 is a schematic diagram illustrating a first side view of a blade prior to its refurbishment.

FIG. 4 is a schematic diagram illustrating the first side view of a blade after its refurbishment.

FIG. 5 is a schematic diagram illustrating a second side view of a blade prior to its refurbishment.

FIG. 6 is a schematic diagram illustrating the second side view of a blade after its refurbishment.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a system and method for blade refurbishment of one or more blades. In particular, for enabling used dicing blades to be refurbished for their reuse in semiconductor wafer dicing operations.

According to the concept of the invention, a used blade is to undergo a combination of steps performed by one or more units of a system for at least one parameter of the blade, which at least includes its blade exposure, to be restored to a prior or original specification, or to be of a modified specification. This involves modification of the blade by removing material from at least one targeted area on a hub of the blade,and removing material from at least one cutting edge of the blade. It is to be noted that the blade, by way of example, is a dicing blade, and it may be in the form of a cutting wheel.

The invention will now be described in greater detail, by way of example, with reference to the drawings.

FIG. 1 illustrates a simplified schematic diagram of the system for blade refurbishment as provided by the present invention. As shown, the system may comprise a receiving unit **101**, a first inspection unit **102**, a first modification unit **103**, a second modification unit **104**, a polishing unit **105**, a dressing unit **106**, a profile checking unit **107**, a cleaning unit **108**, a second inspection unit **109**, a packing unit **110**, and a material review board **111**.

The aforementioned units may be substantially in communication with each other under

a network. These aforementioned units may also be substantially connected with each other via one or more conveying units which may carry blades from one unit to another.

Furthermore, the aforementioned units may be located at different locations, or alternatively, they may be housed within a single machine.

Accordingly, at least one used blade **3a** may be provided into the system for it to be refurbished into a refurbished blade **3b**.

Regarding the receiving unit **101**, it is configured to receive one or more used blades **3a** from a source. In particular, a heap of used blades **3a** may be received by the receiving unit **101** for it to provide each blade to a downstream units in succession.

Regarding the first inspection unit **102**, it is configured to perform inspection upon each blade that is provided thereto as part of incoming material quality control (IQC) . In particular, the first inspection unit **102** may inspect the blade condition of the used blade **3a**. More specifically, the first inspection unit **102** may facilitate inspection of a hub of the used blade **3a** and at least one cutting edge of the used blade **3a** blade to determine the presence of wear and damage on them. In particular, the hub of the used blade **3a** may be made from aluminium.

Regarding the first modification unit **103**, it is configured to modify each blade by removing material from a hub of each blade that is provided thereto. The first modification unit **103** may be further configured to remove material from at least one targeted area on the hub of the blade. The hub of the blade may originally have a first perimeter or circumference, and after removal of material via the first modification unit **103**, the hub of the blade may have a second perimeter or circumference. The material removed from the hub may correspond to an annular area that extends between the first perimeter or circumference and the second perimeter or circumference. By way of

example, the first modification unit **103** may be configured to remove material from the hub of the blade through through mechanical means (e.g. grinding, turning, etc.), chemical means (e.g. acid removal, etc.), or both. By way of a more specific example, the first modification unit **103** performs may turning upon the edges of the hub to remove or shave off its material (e.g. aluminium) from these targeted areas so that the hub of the blade is modified.

Regarding the second modification unit **104**, it is configured to modify each blade that is provided thereto for by either removing material from a cutting edge of the blade, controlling a final outer diameter size of the blade, or a combination thereof. The second modification unit **104** may remove material from at least one targeted area on the cutting edge of the blade for its sharpness to be redefined and/or honed. By way of example, the second modification unit **104** may be configured to remove material from the cutting edge of the blade through through mechanical means (e.g. grinding, turning, etc.), chemical means (e.g. acid removal, etc.), or both. Furthermore, the second modification unit **104** may also be configured to further remove parts of the hub of the blade should it be so desired.

Prior to operation of any one or both modification units **103**, **104**, they may be cleaned and calibrated for them to have optimized parameters.

It is to be noted that in alternative embodiments, the operations of both modification units **103**, **104** may be performed by one single modification unit instead.

Regarding the polishing unit **105**, it is configured to polish each blade that is provided thereto to either expose abrasion-resistant material (i.e. diamonds) on the blade, fine-tune the thickness of the blade, remove scratches from the blade, or a combination thereof.

Regarding the dressing unit **106**, it is configured to dress each blade that is provided thereto, to either further expose abrasion-resistant material (i.e. diamonds) on the blade, remove blade loading, or a combination thereof.

Regarding the profile checking unit **107**, it is configured to check a blade profile of each blade that is provided thereto.

Regarding the cleaning unit **108**, it is configured to clean each blade that is provided thereto. By way of example, the cleaning unit **108** may clean each blade with a chemical wash, a combination of soap and water, or the like.

Regarding the second inspection unit **109**, it is configured to check the blade profile of each blade that is provided thereto, which had been cleaned by the cleaning unit **108**.

Regarding the packing unit **110**, it is configured to pack each blade that is provided thereto for shipment. In particular, at this point, each blade may now be a refurbished blade **3b**, and they may be suitable for reuse in dicing operations.

Regarding the material review board **111**, it is configured to facilitate and/or perform checking of the blade condition of the blade of each blade that is provided thereto. In particular, blades under a failure category that failed inspection or checking are provided thereto. In one embodiment, the material review board **111** may be in the form of one or more persons that performs checking of the blade condition of each blade to further ascertain their suitability for refurbishment. Alternatively, the material review board **111** may be in the form of a computing device with a human-machine interface that may allow one or more users to interact therewith, for the users to review the suitability of each blade for refurbishment.

It is to be noted that the first inspection unit **102**, the profile checking unit **107**, and the

second inspection unit **109** may evaluate one or more parameters of the provided blades. These parameters may include blade grit type, blade grit size, blade bond type, blade concentration, blade exposure, blade kerf width, blade angle, and blade shape, or a combination thereof.

Regarding the first inspection unit **102**, the profile checking unit **107**, and the second inspection unit **109**, they may incorporate one or more components that may include sensing devices such as one or more image sensors for capturing images of each blade, three-dimensional scanners for scanning the geometry of each blade, or the like.

Regarding the first inspection unit **102**, the profile checking unit **107**, and the second inspection unit **109**, they may each further include a processor that operates one or more modules, which may at least include a determination module. The determination module may receive sensor information from one or more sensors to determine whether the used blade falls under a first category (i.e. a pass category) or a second category (i.e. a failure category). The determination of these categories may be based on one or more threshold values. By way of example, should one or more threshold values be exceeded, the blade may be regarded to fall under a second category, else, the blade may be regarded to fall under a first category.

With this, the blades inspected or checked by the first inspection unit **102**, the profile checking unit **107**, or the second inspection unit **109** may then be sorted by a corresponding sorting unit. Blades that fall under a first category may be sorted by the corresponding sorting unit to be passed to a subsequent unit for further processing (i.e. from the first inspection unit **102** to the first modification unit **103**, from the profile checking unit **107** to the cleaning unit **108**, from the second inspection unit **109** to the third inspection unit **110**, etc.). Blades that fall under the second category may be sorted by the corresponding sorting unit to be diverted away from further processing and shall be directed to the material review board **111** for a review of each of their condition.

It is noted that for the rest of the description, the hardware and software components of the system may not be directly implicated. However, it is to be understood by a skilled person that the descriptions of the hardware and software components above provide support for the rest of the description.

FIG. 2 illustrates an example flowchart describing the method for blade refurbishment as provided by the present invention. The steps of **FIG. 2** may be facilitated by an operator that supervises the operations of the units within the system of the present application. It is noted that the steps described in this flowchart are to be interpreted as non-limiting, and minor modifications to the steps (e.g. additions, repititions, omissions, or swaps) are permissible by a skilled person without substantial deviation from as described.

FIG. 2 may begin with step **201**. Step **201** involves receiving one or more blades, by the receiving unit **101**, with these blades preferably being used blades **3a**.

Following step **201** is step **202**. Step **202** involves performing a first inspection upon each blade, by the first inspection unit **102**. More specifically, the first inspection unit **102** may facilitate inspection of a hub of the used blade **3a** and at least one cutting edge of the used blade **3a** blade to determine the presence of wear and damage on them.

Following step **202** is step **203**. Step **203** is a decision step that involves determining a condition of the blade that had been inspected by the first inspection unit **102**. Should the condition of the blade be determined to fall under the first category, step **203** may proceed to step **204**. Else, should the condition of the blade be determined to fall under the second category, step **203** may proceed to step **214**.

Following step **203** is step **204**. Step **204** involves providing at least one used blade **3a** to the first modification unit **103** by placing it thereupon, for the first modification unit

103 to perform the step of modifying at least one used blade **3a**. More specifically, the first modification unit **103** may be invoved in removing material from the hub of the used blade **3a** by removing material from at least one targeted area on the hub through mechanical means (e.g. grinding, turning, etc.), chemical means (e.g. acid removal, etc.), or both.

Following step **204** is step **205**. Step **205** involves providing at least one used blade **3a** to the second modification unit **104** by placing it thereupon, for the second modification unit **103** perform the step of modifyingat least one used blade **3a**. More specifically, the second modification unit **104** may be involved in removing material from at least one cutting edge of the blade, , and controlling a final outer diameter size of the blade, or a combination thereof. Similarly, the second modification unit **104** may remove material through mechanical means (e.g. grinding, turning, etc.), chemical means (e.g. acid removal, etc.), or both.

In embodiments where the modification units **103**, **104** remove material through mechanical means, prior to steps **204** and **205**, or prior to the method of the present invention is performed, each modification unit **103**, **104** may be, by way of example, installed with a grinding wheel. The grinding wheel is ensured to be properly aligned and tightened to their respective modification unit **103**, **104**. As the grinding wheel is installed onto their respective modification unit **103**, **104**, an exposure of the grinding wheel may be determined based on [i] a set of predetermined guidelines that are set forth by the manufacturer or the used blade **3a** for it to be restored to its prior or original spectification, [ii] a modified blade specification that is different from a prior or original specification, which is intended to be achieved for the used blade **3a** as set forth by the operator, or a combination thereof.

It is to be noted that for steps **204** and **205**, the removal of material from the hub and/or cutting edge of the blade performed by the modification units **103**, **104** may be done in

a controlled manner. In embodiments where the modification units **103**, **104** remove material through mechanical means, the modification units **103**, **104** may be configured for their grinding wheel to initially rotate at a first speed. This speed may be low so that it may be ensured that the process remains under control. With that, the modification units **103**, **104** may then gradually increase the speed of rotation of their grinding wheels for them to reach a second speed that is higher than the first speed. As this occurs, pressure may be lightly applied onto the hub of the used blade **3a** for modifiying the hub and/or portions of the blade. This may be performed by the operator and/or the modification units **103**, **104**.

It is to be noted that for steps **204** and **205**, as the blades are modified is by the modification units **103**, **104**, there may be a further step that involves checking an exposure length of the blade that is undergoing material removal at regular or irregular intervals. During this step, the modification units **103**, **104** may be stopped for the hub and/or portions of the blade to be checked to ensure that its surfaces are smooth and even. All of this may be performed by the operator and/or the modification units **103**, **104**.

It is to be noted that in alternative embodiments, steps **204** and **205** may be performed by one single modification unit. With that, the descriptions described for the modification units **103**, **104** may be applicable for one single modification unit. In embodiments where the modification units **103**, **104** remove material through mechanical means, the modification of the hub and/or portions of the blade are performed by a single grinding wheel that is appriopiately installed thereonto.

Following step **205** is step **206**. Step **206** involves polishing each blade, by the polishing unit **105**, to either expose abrasion-resistant material (i.e. diamonds) on the blade, fine-tune the thickness of the blade, remove scratches from the blade, or a combination thereof.

Following step **206** is step **207**. Step **207** involves dressing each blade, by the dressing unit **106** to either further expose abrasion-resistant material (i.e. diamonds) on the blade, remove blade loading, or a combination thereof.

Following step **207** is step **208**. Step **208** involves checking a blade profile of each blade, by the profile checking unit **107**.

Following step **208** is step **209**. Step **209** is a decision step that involves determining whether or not the blade profile of the blade checked by the profile checking unit **107** falls under a first category or a second category. Should the blade be determined to fall under the first category, step **209** may proceed to step **210**. Else, should the blade be determined to fall under the second category, step **209** may proceed to step **214**.

Following step **209** is step **210**. Step **210** involves cleaning each blade, by the cleaning unit **108**. Preferably, during this step, any one or a combination of dust, leftover material, and material residue, which may have resulted from the modification of the hub, modification of the cutting edge of the blade,, dressing, or polishing, may be removed from the hub and/or portions of each blade.

Following step **210** is step **211**. Step **211** involves inspecting the blade condition of each blade, by the second inspection unit **109**.

Following step **211** is step **212**. Step **212** is a decision step that involves determining whether or not the blade condition of the blade inspected by the second inspection unit **109** falls under a first category or a second category. Should the blade be determined to fall under the first category, step **212** may proceed to step **213**. Else, should the blade be determined to fall under the second category, step **212** may proceed to step **214**.

It is to be noted that, at this point, the second inspection unit **109** may receive one or more refurbished blades **3b**.

The second inspection unit **109** may be further configured to facilitate or assist the operator in performing a quality check upon the refurbished blades to ensure that they are each physically fit and in good condition.

The second inspection unit **109** may be configured to facilitate or assist the operator in measuring the exposure length of the refurbished blade blade in a repeated manner to ensure that it is correct.

The second inspection unit **109** may be further configured to facilitate or assist the operator in recording down the final measurements and taking down notes about the refurbished blade that is being inspected. In alternative embodiments, these may not be performed by the second inspection unit **109** and may be fully performed by the operator.

The second inspection unit **109** may be further configured to facilitate or assist the operator in recording all measurements, modification settings, and results relevant to the refurbished blade for them to be stored in a database for future reference.

In alternative embodiments, one or a combination of steps relevant to the second inspection unit **109** may not be performed by the second inspection unit **109**, and may be fully performed by the operator.

Step **213** may follow from Step **212**, and may be regarded a final step of the flowchart. In particular, Step **213** involves packing each blade, by the packing unit **110**, for shipment.

Step **214** may follow from either one of step **203**, step **209**, or step **212**, and may be regarded as yet another final step of the flowchart. In particular, Step **214** may involve reviewing each blade, by the material review board **111**, for their suitability for refurbishment.

In particular, besides restoration of the blade exposure of the blade to a prior or original specification, or to be of a modified specification, other parameters such as any one or a combination of blade grit size, blade concentration, blade kerf width, blade angle, and blade shape, may be restored to a prior or original specification, or to be of modified specification as well.

Widlst not shown in **FIGS 1 – 2**, there may further be a third inspection unit that is configured to perform inspection upon blades packed by the packing unit **110** prior to its shipment. In particular, the third inspection unit may be configured similarly as the first inspection unit **102**, the profile checking unit **107**, or the second inspection unit **109**. The third inspection unit may be further configured to perform optical inspection for quality control. The third inspection unit may be further configured to determine the quality of the inspected packed blades. Should the packed blades be determined to fall under the first category, they may be processed for shipment. Else, should the packed blades be determined to fall under the second category, they may be provided to the material review board **111** for review of each of their suitability for shipping.

FIGS 3 – 6 are views of a blade prior to its refurbishment and after its refurbishment. In particular, **FIG. 3** illustrates a first side view of a used blade **3a**, while **FIG. 4** illustrates a first side view of a refurbished blade **3b**. In particular, **FIG. 5** illustrates a second side view of the used blade **3a**, while **FIG. 6** illustrates a second side view of the refurbished blade **3b**.

As shown in **FIGS 3** and **5**, the used blade **3a** has a hub **31a** and a cutting edge **32a**. The hub **31a** may or may not have its prior or original sizing and dimensions. The

cutting edge **32a** may be worn or dulled, and have may parameters that are different from its prior or original, specifications. Further shown in **FIGS 3** and **5** are that the used blade **3a** may have insufficient or diminished blade exposure.

As shown in **FIGS 4** and **6**, the refurbished blade **3b** has a hub **31b** and a cutting edge **32b**. The hub **31b** may have been processed by the aforementioned system and method of the present invention to have a sizing and dimensions that is diminished compared to its original, or prior, sizing and dimensions. The cutting edge **32b** may have parameters that are restored to its prior or original specifications, or parameters corresponding to a modified specification that is different from the prior or original specifications. Further shown in **FIGS 4** and **6** are that the refurbished blade **3b** may be restored to have its prior, or original blade exposure, or a modified blade exposure that is different from its prior or original blade exposure.

With this, a system and method for blade refurbishment of one or more blades have been described. Whidlst it has been described that the invention is to be applicable on dicing blades for their resue in semiconductor dicing operations, it is to be noted that the application of the invention may further be extended for refurbishing blades of any other technical field for their resue in intended operations. It is also to be understood that the described system and method for blade refurbishment also provides, describes, and/or manufactures at least one refurbished blade whose attributes and/or characteristics are imparted therefrom.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form, it is understood that the present disclosure of the preferred form has been made only by way of example and numerous changes in the details of the construction, combination and arrangements of parts may be resorted to without departing from the scope of the invention.

CLAIMS

1. A system for blade refurbishment of one or more blades, comprising
one or more modification units (103, 104), which are provided with the blades;
wherein the modification units (103, 104) are configured to either remove material from a hub of each blade, remove material from at least one cutting edge of each blade, or both, for at least one parameter of each blade, which at least includes its blade exposure, to be restored to a prior or original specification, or to be of a modified specification.

2. The system according to claim 1, wherein the modification units (103, 104) are further configured to control an outer diameter size of each blade.

3. The system according to claim 1 or 2, further comprising a polishing unit (105) that is provided with the blades, the polishing unit (105) configured to either
polish each blade to expose its abrasion-resistant material;
fine-tune a thickness of each blade;
remove scratches from each blade;
or a combination thereof.

4. The system according to any one of claims 1 to 3, further comprising a dressing unit (106) that is provided with the blades, the dressing unit (106) configured to either
dress each blade to further expose its abrasion-resistant material;
remove blade loading;
or a combination thereof.

5. The system according to any one of the preceding claims, further comprising a cleaning unit (108) that is provided with the blades, the cleaning unit (108) configured to clean each blade.

6. The system according to any one of the preceding claims, further comprising a packing unit (110) that is provided with the blades, the packing unit (110) configured to pack the blades into one or more packages.

7. The system according to any one of the preceding claims, further comprising a first inspection unit (102) that is provided with the blades, the first inspection unit (102) configured to inspect a blade condition of each blade.

8. The system according to any one of the preceding claims, further comprising a second inspection unit (109) that is provided with the blades, the second inspection unit (109) configured to inspect a blade profile of each blade.

9. A method for blade refurbishment of one or more blades, comprising the step of providing the blades to one or more modification units (103, 104) ;

wherein the modification units (103, 104) are configured to either remove material from a hub of each blade, remove material from at least one cutting edge of each blade, or both, for at least one parameter of each blade, which at least includes its blade exposure, to be restored to a prior or original specification, or to be of a modified specification.

10. A refurbished blade, wherein the blade has material removed from its hub removed, material removed from at least one of its cutting edge, or both, by one or more modification units (103, 104), for at least one parameters of the blade, which at least includes its blade exposure, to be restored to a prior or original specification, or to be of a modified specification.