VARIABLE PRESSURE BRUSH/PAD

BACKGROUND

[0001] Many processes for semiconductor and disk manufacturing require extremely clean workpieces before the processes may start. For example, particulates or contaminates that attach to or form on the workpiece before processing may eventually cause defects in the workpiece. When the workpieces are disks to be processed, such particulates or contaminates may be hydrophobic or hydrophylic, and may include layers: e.g., thin oxide surface layers; surface asperities such as scratches, nodules, and ridges that may be induced by a prior polishing operation; materials adhered to the workpiece due to the polishing operation; and loosely adhered particles from the environment in which the workpiece has been stored. These particulates or contaminates may also be aged, and thus be more stable and more difficult to remove before the processing. Cleaning, then, is a process intended to remove substantially all of such particulates or contaminates from workpieces before processing, such as processing of magnetic media or semiconductor workpieces. A clean workpiece is thus a workpiece from which substantially all of such particulates or contaminates have been removed before processing.

[0002] Therefore, there is a need for improving techniques for cleaning workpieces, such as those workpieces that present problems and require removal of substantially all of such particulates or contaminates from the workpieces before processing. Moreover, these improved techniques must allow cleaning of a workpiece to be done quickly so as to reduce the cost of capital equipment for the cleaning.

[0003] It is within this context that embodiments of the invention arise.

SUMMARY OF THE INVENTION

[0004] Broadly speaking, embodiments of the present invention fill these needs by providing methods of and apparatus configured to efficiently clean workpieces, especially substrates for the disk drive manufacturing process.

[0005] In one embodiment, a brush for cleaning a workpiece is provided. The brush includes a rigid core having first and second portions affixed to each other. The rigid core has

an aperture defined around an axis of rotation of the rigid core. A fluid channel is defined between opposing surfaces of the first and second portions. The fluid channel extends radially from a surface defining the aperture. First and second membranes are affixed to outer surfaces of the first and second portions, wherein movement of the first and second membranes is controlled through introduction of a fluid through the fluid channel. In one embodiment, the membrane is porous and the fluid is a cleaning fluid that contacts the workpiece, such as a magnetic disc or semiconductor substrate for cleaning.

[0006] In another embodiment, a cleaning apparatus for cleaning a workpiece is provided. The apparatus includes a rigid cylindrical core having a surface with a plurality of openings. The rigid cylindrical core is rotatable about an axis, wherein a fluid plenum is defined within inner walls of the cylindrical core. Brushes are spaced apart and extend outward from each of the plurality of openings, the brushes have an inner tube in fluid communication with corresponding openings. The inner tube is surrounded by a brush material. In one embodiment, the inner tube expands and contracts according to the pressure provided by a fluid introduced from the fluid plenum. In another embodiment, a flexible membrane is disposed around the inner tube and the flexible membrane expands and contracts according to the pressure provided by a fluid introduced from the fluid plenum. In either embodiment, a gap between the brushes is adjusted by the expansion and contraction capabilities.

[0007] Other aspects and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention, together with further advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings.

[0009] Figure 1 is a simplified schematic diagram illustrating a system for cleaning workpieces in accordance with one embodiment of the invention.

[0010] Figure 2A is an exemplary illustration of a support structure in accordance with one embodiment of the present invention.

[0011] Figure 2B is a simplified schematic diagram illustrating a cleaning apparatus with a plurality of variable brushes/pads in accordance with one embodiment of the invention.

[0012] Figure 3A is a simplified schematic diagram illustrating a variable pressure brush\pad in accordance with one embodiment of the invention.

[0013] Figure 3B is a simplified schematic diagram illustrating a variable pressure brush having an outer layer removed in accordance with one embodiment of the invention.

[0014] Figure 3C is a simplified schematic diagram illustrating removal of a brush portion and an underlying flexible membrane in order to illustrate a rigid core of the brush in accordance with one embodiment of the invention.

[0015] Figure 4 is a simplified schematic diagram illustrating a cross sectional view of the rigid core in accordance with one embodiment of the invention.

[0016] Figure 5A is a simplified schematic diagram illustrating an alternative rigid core for the variable pressure brush\pad in accordance with one embodiment of the invention.

[0017] Figure 5B is a simplified schematic diagram illustrating a cross-sectional view of the rigid core of Figure 5A.

[0018] Figure 6A is a simplified schematic diagram illustrating a cleaning system for a single disc in accordance with one embodiment of the invention.

[0019] Figure 6B is a simplified schematic diagram illustrating a side view of the cleaning system for a single disc of Figure 6A.

[0020] Figure 7A is a simplified schematic diagram illustrating an alternative embodiment for a variable pressure brush\pad cleaning system.

[0021] Figure 7B is a cross-sectional illustration of the variable pressure brush\pad cleaning system of Figure 7A.

[0022] Figure 8 is a simplified schematic diagram illustrating a cylindrical core with the brushes being removed in accordance with one embodiment of the invention.

[0023] Figure 9A is a simplified schematic diagram illustrating and expandable brush in accordance with one embodiment of the invention.

[0024] Figure 9B is a simplified schematic diagram illustrating a cross-sectional view of the brush of Figure 9A.

DETAILED DESCRIPTION

[0025] The embodiments described below relate to an apparatus for cleaning a workpiece. In one embodiment, the apparatus may be used to clean magnetic disks that store data. It should be appreciated that the embodiments are not limited to cleaning magnetic disks, in that any semiconductor circuit device, flat panel display, or other substrate may be supported for cleaning by the embodiments described herein. The term workpiece as used herein may refer to any substrate being processed. In addition, the terms disk and disc are used interchangeably, and may also reference any such substrate or workpiece.

[0026] The embodiments provide a brush/pad for cleaning a workpiece. The brush/pad includes a flexible membrane that can expand and retract to modify the amount of pressure exerted by the brush/pad surface against the workpiece surface. In addition, different size workpieces may be cleaned contemporaneously through the embodiments described below. The terms brush and pad are used interchangeably and the embodiments are not meant to be limited to either a brush or a pad. In addition, the embodiments may be employed with semiconductor processes for cleaning semiconductor substrates, which include magnetic discs.

[0027] Figure 1 is a simplified schematic diagram illustrating a system for cleaning workpieces in accordance with one embodiment of the invention. System 80 includes support structure 100 for supporting a plurality of disks 106. Support structure 100 is capable of vertically translating along posts 82a and 82b. Support structure 100 is driven by air cylinder 92 disposed thereunder. Support structure 100 may support discs 106. In one embodiment, support structure 100 is configured to remove and return discs 106 from nest 90. As will be explained in more detail below the variable pressure pads 130 provide for the efficient cleaning of disks 106. Variable pressure pads 130 are disposed around shaft 120 and driven by shaft 120 in accordance with one embodiment. It should be appreciated that system 80 is an exemplary system and not meant to be limiting as the variable pressure brushes and pads may be utilized with any suitable system in which a workpiece is to be cleaned.

[0028] Figure 2A is an exemplary illustration of a support structure 100 in accordance with one embodiment of the present invention. Support structure 100 includes frame 104a and frame 104b along with roller assemblies 102a, 102b, and 102c disposed between opposing surfaces of frames 104a and 104b. Removable fasteners can be used to secure the roller assemblies 102a, 102b and 103c between the opposing surfaces of frame 104a and

104b. In one embodiment, the removable fasteners are machine screws while other embodiments employ other known types of fasteners. Roller assemblies 102a and 102b support a disc 106 vertically while roller assembly 102c supports the disk 106 horizontally. In some embodiments, a moveable fourth roller assembly (not shown) is used to hold the disc 102 in place during cleaning operations. The moveable fourth roller assembly can be secured to the frames 104a and 104b or be part of a separate assembly.

[0029] While illustrated with a disc 106, the roller assemblies are configured to accommodate multiple discs that are placed into the support structure 100 by an automated carrier moving between roller assembly 102a and roller assembly 102b. The distance between roller assembly 102a and roller assembly 102b defines the width of a support nest of Figure 1. Features of the roller assembly 102a and 102b enable support nests that can accommodate large diameter discs while in other configurations enabling accommodation of smaller diameter discs. Note that the relative size of the support structure 100 shown in Figure 1B is not intended to be limiting. The support structure 100 can be modified in order to accommodate more or fewer discs. Further details of the support structure may be found in U.S. Patent Application No. 12/359,173, the contents of which are incorporated herein by reference.

[0030] Figure 2B is a simplified schematic diagram illustrating a cleaning apparatus with a plurality of variable pressure brushes/pads in accordance with one embodiment of the invention. The support structure of Figure 2A may be used in conjunction with the cleaning apparatus of Figure 2B in one embodiment. In one embodiment, the apparatus of Figure 2B is a spiral scrubber that conditions the surface of the discs by removing residual particulate matter. In another embodiment, brushes/pads 130 are individual brushes/pads that are disposed over shaft 120 and the gap between adjacent brushes/pads is adjustable according to the fluid pressure delivered to each of the brushes/pads through the shaft. It should be appreciated that the end supports illustrated in Figure 6A may be included so as to contain the brushes/pads within a fixed area on the shaft. As described below, brushes/pads 130 may have a rigid core over which a flexible membrane and brush material are disposed. This flexible membrane can be made to expand from the core and contract to the core based on the pressure created through the introduction of fluid between the core surface and a surface of the flexible membrane. For an alternative embodiment, regarding the use of the variable pressure brushes/pads 130 described herein, with the spiral scrubber, see U.S. Patent Application No. 11/862,170 for further details on the structure of the spiral scrubber and the

shaft for delivering the fluid to the variable pressure brushes/pads. The contents of U.S. Patent Application No. 11/862,170 are incorporated herein by reference.

[0031] Referring to Figures 2A and 2B, roller assembly 102 of the support structure 100 allows the discs to rotate so the entire surface of the discs can be exposed to the cleaning apparatus. Additionally, the v-shape groove of the individual rollers encourages even spacing of the discs and minimizes contact with discs 106. It should be noted that the support structure can be moved into position onto a processing tool via a robot in order to minimize human contact and possible contamination points. The individual brushes/pads may be compartmentalized as described below. In addition, there may be grooves 101 defined on a surface of brushes/pads 130, whether or not the brushes/pads are compartmentalized. It should be appreciated that where brushes/pads 130 are compartmentalized, grooves 101 may coincide with the space between the compartments or sections.

[0032] Figure 3A is a simplified schematic diagram illustrating a variable pressure brush\pad 130 in accordance with one embodiment of the invention. Brush 130 is a circular brush in which a number of individual brushes 136a through 136f are defined over corresponding compartments. Brush 130 includes a rigid core 138 that defines a central aperture 134. Aperture 134 may be slidably mounted on a shaft in accordance with one embodiment. As described above, the shaft may provide fluid to multiple fluid channels 132. The fluid will be disbursed into the various compartments 136a through 136f in order to vary a gap, and therefore the pressure between corresponding brushes 130. One skilled in the art will appreciate that while six compartments are illustrated on the brush/pad, more or less compartments may be included in alternative embodiments.

[0033] Figure 3B is a simplified schematic diagram illustrating a variable pressure brush having an outer layer removed from a portion of the brush in accordance with one embodiment of the invention. Brush\pad 130 has the outer layer 135 for brush 130 removed from a portion of the surface of brush\pad 130, for illustrative purposes. Underneath the outer layer 135 material, which may be a brush material such as polyvinyl alcohol (PVA), is a flexible membrane 140. In one embodiment, flexible membrane 140 includes a plurality of holes 142. That is, flexible membrane 140 may be porous in one embodiment. It should be appreciated that flexible membrane 140 may be nonporous in another embodiment. Where flexible membrane 140 is porous the fluid used to contract and expand the flexible membrane 140, and consequently brush 130, may also be used to deliver fluids to the workpiece. One skilled in the art will appreciate that any of the commonly used cleaning materials for

semiconductor substrates or magnetic discs may be employed as the fluids. Flexible membrane 140 is bonded to opposing surfaces of rigid core 138 in one embodiment. Rigid core 138 includes fluid channels 132 for introducing a fluid to the inner region or cavity defined through flexible membrane 140 as the flexible membrane 140 covers the opposing surfaces of rigid core 138. Flexible membrane 140 is composed of material capable of expanding and contracting according to the introduction of fluid into an area enclosed by the flexible membrane. The flexible membrane material includes rubber, polyvinyl chloride (PVC), ethylene propylene diene Monomer (EPDM), and high-density polyethylene (HDPE).

[0034] Figure 3C is a simplified schematic diagram illustrating removal of a brush portion and an underlying flexible membrane in order to illustrate a rigid core of the brush in accordance with one embodiment of the invention. Brush 130 includes rigid core 138. Rigid core 138 has raised extensions 154 extending radially outward toward outer rim 156 of rigid core 138. Within rigid core 138 are a plurality of openings 152. Fluid channels 132 deliver fluid to a gap defined between the flexible membrane and a surface of rigid core 138 when two rigid cores 138 are assembled back-to-back. Openings 152 provide for the equalization of pressure on opposing sides of assembled rigid cores 138. In one embodiment rigid core 138 includes two portions which are mated together in a back to back configuration as illustrated further below. The mating together of the two portions define fluid channel 132, in one embodiment. That is, a portion of the fluid channel is defined in each of the mated portions of rigid core 138.

[0035] Figure 4 is a simplified schematic diagram illustrating a cross sectional view of the rigid core in accordance with one embodiment of the invention. Rigid core 138 is illustrated as one portion which can be mated to another portion in accordance with one embodiment of the invention. That is, a mirror image of the portion illustrated in Figure 4 is affixed to the illustrated portion in order to define the complete rigid core. Aperture 134 is defined in the central portion of rigid core 138. Fluid channels 132 are defined on each portion of rigid core 138 and enable delivery of a fluid into the compartments defined within the rigid core. The fluid can then equalize the pressure on the flexible membrane through openings 152. In the illustration of Figure 4 six compartments are defined between extensions 154, inner rim 155, and outer rim 156, however, this is not meant to be limiting. In addition, even though six compartments are defined, there need not be a one to one correspondence between the compartments and the compartments for the brush/pad segment. That is, there may be a number of compartments formed on the rigid core 138, but the flexible membrane

may be one continuous piece, or some other configuration, rather than having compartments coinciding with the rigid core.

[0036] Figure 5A is a simplified schematic diagram illustrating an alternative rigid core configuration for the variable pressure brush\pad in accordance with one embodiment of the invention. Rigid core 138 is comprised of two portions which are mated together in a back to back configuration and has a central opening 134 wherein fluid channels 132 are defined on an inner surface of the structure defining aperture 134. Extensions 154 and outer rim 156, along with inner rim 155 defining compartments 160. In this embodiment a flexible membrane is disposed over rigid core 138 and may be bonded to inner rim 155 extensions 154 and outer rim 156, in order to enclose each compartment 160. One skilled in the art will appreciate that the pressure for each compartment controlled by the introduction of fluid through fluid channels 132 may be independently controlled. That is, through a shaft having a plurality of fluid delivery lines where each delivery line is in communication with corresponding compartments through respective fluid channels 132, the expansion and contraction for each of compartments 160 may be varied independently.

[0037] Figure 5B is a simplified schematic diagram illustrating one portion of the back to back configuration of the rigid core of Figure 5A. The portion of rigid core 150 illustrated in Figure 5B is combined with a mirror image portion to complete the rigid core in one embodiment. Fluid delivery channels 132 extend from aperture 134 to cavities 160 defined between extensions 154, outer rim 156 and inner rim 155. Thus, as fluid is introduced into the cavities from fluid channels 132, the flexible membrane will expand to reduce a gap between adjacent brushes/pads to provide the variable pressure for the cleaning apparatus. It should be appreciated that the rigid core discussed herein may be composed of any rigid material compatible with the fluid and cleaning operation, such as plastics, metals or composites, etc.

[0038] Figure 6A is a simplified schematic diagram illustrating a cleaning system for a single disc in accordance with one embodiment of the invention. Disc 106 is inserted between brushes 130a and 130b. End supports 160a and 160b are provided so that the expansion of brushes 130a and 130b is contained. One skilled in the art will appreciate that end supports 160a 160b may encompass a plurality of brushes 130 along to a length of a shaft. End supports 160a 160b are anchored to their respective positions in order to secure the variable pressure brushes and contain the outward expansion of the brushes. In one

embodiment, brushes 130a and 130b of Figure 6A have flexible membranes disposed on a single side of the respective rigid cores.

[0039] Figure 6B is a simplified schematic diagram illustrating a side view of the cleaning system for a single disc of Figure 6A. End supports 160a 160b contain brushes 130a and 130b disposed on shaft 120. Disc 106 is inserted between brushes 130a and 130b. Through the embodiments described herein a fluid introduced into the rigid core of brushes 130a and 130b through shaft 120 causes brushes 130a and 130b to expand in order to provide variable pressure cleaning against the surfaces of disc 106 in each slot position of the cleaning apparatus. Thus, through the embodiments described herein different disc shapes or sizes may be cleaned concurrently within a single tool. In addition, a set of the same set of discs may have substantially equivalent pressures applied or different pressures as desired through the embodiments described herein.

[0040] Figure 7A is a simplified schematic diagram illustrating an alternative embodiment for a variable pressure brush\pad cleaning system. Cleaning brushes 200a and 200b have a plurality of brush extensions 204 extending from a cylindrical core 202a and 202b, respectively. Discs 106a and 106b are illustrated between brushes 200a and 200b. Brush extensions 204 are affixed to respective cylindrical cores 202a and 202b. The membranes for brush extensions 204 are capable of contracting and expanding through the introduction of fluid through cylindrical cores 202a and 202b and subsequently into brush extensions 204. The rotation for brushes 200a and 200b may be in opposite directions or the same direction. For example, brush 200a and 200b may both rotate in a clockwise direction in one embodiment.

[0041] Figure 7B is a cross-sectional illustration of the variable pressure brush\pad cleaning system of Figure 7A. Cylindrical cores 202a and 202b are illustrated with a plurality of openings extending through the core walls. The openings are placed along parallel rows. In one embodiment, the openings provide access for fluid into tubes 210, which extend through the openings. Tubes 210 provide a fluid passageway into the brushes 204 extending from the cylindrical cores.

[0042] Figure 8 is a simplified schematic diagram illustrating a cylindrical core with the brushes attached and a cylindrical core with the brushes being removed in accordance with one embodiment of the invention. Cylindrical core 202a is illustrated with the brushes being removed for purposes of clarity. A plurality of holes or openings 212 are defined along a length of cylindrical core 202a. In this illustration the plurality of openings 212 are defined

along spaced apart rows that are substantially parallel. This configuration is exemplary and not meant to be limiting, as one skilled in the art will appreciate that any suitable placement of the holes may be provided with the embodiments defined herein. Brush 200b is illustrated having brushes 204 extending from the cylindrical core. As illustrated in Figure 8, tubes 210 extend through the wall of the cylindrical core to access the inner surface of the cylindrical core. Thus, fluid delivered to the inner core area of the cylindrical cores will be passed through tubes 210 to respective brushes. The pressure and volume of fluid flowing to brushes 204 will dictate the amount of expansion of the brush members in order to control a gap in which discs 106a or 106b reside in.

[0043] Figure 9A is a simplified schematic diagram illustrating and expandable brush in accordance with one embodiment of the invention. Brush 204 has tube 210 extending along a length of the brush. One end of tube 210 is inserted into the holes of the cylindrical core as illustrated in Figure 8, while the other hand is capped. Disposed over tube 210 is brush 214. Brush 214 may be any suitable brush material utilized for cleaning magnetic disks, semiconductor substrates, etc. Groove 216 is defined along the length of brush 214 in one embodiment. Groove 216 enables particles to be removed through the groove as the disc or workpiece is being cleaned. In one embodiment the shape of groove 216 is a V-shape, however, the shape is not limited to a V groove as any recessed groove will be suitable for the embodiments described herein.

[0044] Figure 9B is a simplified schematic diagram illustrating a cross-sectional view of a brush in accordance with one embodiment of the invention. Tube 210 extends along the length of brush 204. The walls of tube 210 define a plurality of openings 220 that extend through the tube wall. Brush material 214 is disposed around tube 210. In one embodiment tube 210 is composed of a flexible membrane. In another embodiment tube 210 is a rigid material. Where tube 210 is a rigid material, brush 214 may include a flexible membrane that will contract and expand according to an amount of pressure from the fluid being delivered from tube 210, through openings 220 to the flexible membrane disposed between the brush material 214 and an outer surface of tube 210. Thus, the expansion of the flexible membrane will cause the brush to expand.

[0045] 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 may be practiced within the scope of the appended claims. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and 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. A brush for cleaning a workpiece, comprising:

a rigid core

first and second membranes affixed to outer surfaces of the rigid core; and

brushes affixed to outer surfaces of the membranes , wherein movement of the first and second membranes, and movement of the brushes, is controlled through introduction of a fluid between the membranes.

2. The brush of claim 1, wherein the first and second membranes are porous and the fluid contacts the workpiece during the cleaning.

3. The brush of claim 1, wherein the first and second membranes have a pad material affixed thereto.

4. The brush of claim 1, wherein the rigid core consists of first and second portions affixed to each other, the rigid core having an aperture defined around an axis of rotation of the rigid core, a fluid channel defined between opposing surfaces of the first and second portions, the fluid channel extending radially from a surface defining the aperture.

5. The brush of claim 4, wherein the first and second portions include a plurality of extensions extending from a surface defining the aperture to a peripheral rim concentric with the aperture.

6. The brush of claim 5, wherein cavities are defined between each of the plurality of the extensions, the peripheral rim and a surface defining the aperture.

7. The brush of claim 6, wherein fluid delivery to each of the cavities is independently controllable.

8. The brush of claim 4, wherein the aperture of the rigid core is disposed over a shaft, the shaft delivering the fluid to the fluid channel.

9. An apparatus for cleaning a workpiece, comprising:

a plurality of spaced apart cleaning elements disposed along a length of a shaft, the plurality of spaced apart cleaning elements each having a rigid core with an aperture accommodating the shaft, the rigid core defining a fluid channel extending from the aperture,

the rigid core having a flexible membrane extending radially to a perimeter of the rigid core, wherein the fluid channel enables access for a fluid to cause the flexible membrane to expand and contract.

10. The apparatus of claim 9, wherein the shaft includes a fluid delivery channel aligned with the fluid channel.

11. The apparatus of claim 9, further comprising:

first and second anchors affixed to respective ends of the shaft, the plurality of spaced apart cleaning elements being disposed between the first and second anchors, each of the first and the second anchors having the rigid core with the flexible membrane extending over a single side of the rigid core.

12. The apparatus of claim 9, wherein the flexible membrane is porous and wherein the fluid contacts the workpiece to clean the workpiece.

13. The apparatus of claim 9, wherein the flexible membrane has a layer composed of polyvinyl alcohol disposed thereover.

14. The apparatus of claim 9, wherein the rigid core is compartmentalized by a plurality of extensions radially extending from a surface defining the aperture to an outer rim of the rigid core and wherein the flexible membrane is affixed to a surface of each of the extensions and the outer rim.

15. The apparatus of claim 9, wherein the rigid core is defined by a first and a second member, and wherein the fluid channel is partially formed in the first and second members.

16. The apparatus of claim 14, wherein expansion and contraction of each compartmentalized section independently controllable.

17. A workpiece cleaning apparatus, comprising:

a rigid cylindrical core having a surface with a plurality of openings, the rigid cylindrical core rotatable about an axis, wherein a fluid plenum is defined within inner walls of the cylindrical core; and

brushes spaced apart and extending outward from each of the plurality of openings, the brushes having a flexible inner tube in fluid communication with corresponding openings, the flexible inner tube surrounded by a brush material, wherein the flexible inner tube expands

and contracts according to a fluid introduced from the fluid plenum, thereby adjusting a gap between the brushes.

18. The workpiece cleaning apparatus of claim 17, wherein the flexible inner tube is curved in a direction opposing a direction of rotation for the rigid cylindrical core and wherein the flexible inner tube extends through the cylindrical core into the fluid plenum.

19. The workpiece cleaning apparatus of claim 17, wherein the flexible inner tube is porous.

20. The workpiece cleaning apparatus of claim 17, wherein an outer surface of the brush material has a groove defined thereon, the groove extending along a length of the brush material.

21. The workpiece cleaning apparatus of claim 17, wherein the apparatus is included with a second workpiece cleaning apparatus proximately located therewith, the second workpiece cleaning apparatus rotating in an opposite direction to the workpiece cleaning apparatus, and wherein workpieces of varying sizes are cleaned contemporaneously when inserted into gaps between the brushes of the workpiece cleaning apparatuses.