

Description

This invention relates in general, to semiconductor wafer processing equipment, and more particularly to an apparatus for polishing a semiconductor wafer made of silicon or other material that is used in the fabrication of a semiconductor device.

Semiconductor devices are manufactured on a substrate which is usually made from silicon or the like. The substrate or wafers, are sliced from ingots of various sizes. This slicing process causes surface damage and leaves the wafer with thickness variations and deviations from parallelism. To improve the wafer flatness and parallelism and eliminate saw marks and surface damage, the wafers are sent through a lapping or grinding, and an etching and polishing process.

The rough surface of a lapped wafer is usually etched to remove sub-surface damage, then polished to a flat mirror finish before the wafer is suitable for processing into semiconductor devices. The polished wafer must be free from defects and be extremely flat, especially when the wafer is used for sub-micron devices.

Polishing wafers is usually a two part process in which the first part, or primary polish, is stock removal. During primary polish, approximately 17 micrometers of material are removed from each wafer. During the next step, final polishing, only a very small amount of material is removed. Both primary polish and final polish are done on the same type of machine but with different slurries and pads. Since final polishing takes only about twenty percent of the time that primary polishing takes, there may be four or five primary polishing machines for each machine used for final polishing.

It was found that the existing polishing equipment was not capable of producing the high quality flat finish necessary for the starting material of a sophisticated integrated circuit. It was also found that over two percent of the wafers were damaged due to the manual handling of the wafers during the unloading of the primary polisher, transporting the wafers, and loading the final polisher.

A need therefore existed for an automatic polishing system that could do both the primary and the final polish and still produce large diameter, ultra flat, defect free wafers, with a minimum amount of operator handling.

US-A-4,141,180 which forms the basis for the pre-characterising parts of claims 1 and 9 discloses the use of a pivotable arm carrying a pressure head which picks up a wafer by applying a vacuum, and moving the wafer between a pick up station, primary and secondary polishing stations and a receiving station. However there remain problems in damage caused to the wafer during

the pick up operation between the various stations.

Summary of the Invention

It is an object of the present invention to overcome the problems of wafer damage during the handling between various wafer treatment stations.

The present invention provides an apparatus for polishing a semiconductor wafer, including a plurality of wafer polishers, each wafer polisher having load and unload stations; a robot arm having attached thereto pick up means for picking up wafers, characterised by:

a wafer cassette handling system having load and unload stations each of the load and unload stations including a container for water so that the wafers can be loaded and unloaded underwater,

said pick up means including means for creating a Bernoulli effect whereby in use a wafer is moved underwater towards the pick up means by a low pressure region created by a high pressure stream of water and the wafer is then picked up so as to transfer wafers from the unload station of the wafer cassette handling system to a wafer polisher and for transferring the wafers from a wafer polisher to the load station of the wafer cassette handling system.

In another aspect the invention provides a method for polishing a semiconductor wafer, employing a robot arm having a pick up for moving wafers between load and unload station characterized by the steps of:

loading a cassette of wafers onto a wafer handling system;

cleaning the wafers with a brush scrub which is located on the wafer handling system;

sending the wafers to an unload station on the wafer handling system, where the wafers are placed underwater;

obtaining the wafers from the unload station of the wafer handling system with a robot arm using a wafer pickup which provides a high pressure stream of water to create a low pressure region by means of the Bernoulli effect so that a wafer is moved underwater towards the pickup;

depositing the wafers into a load station of a wafer polisher; and

polishing the wafers on the wafer polisher.

Brief Description of the Drawings

Fig. 1 illustrates a top view of a wafer polishing system in accordance with the present invention;

Fig. 2 illustrates a top view of a wafer cassette handling system used in the wafer polishing system of Fig. 1;

Fig. 3 illustrates a side view of an underwater

load station that is located in the wafer cassette handling system of Fig. 2; and

Fig. 4 illustrates a side view of a Bernoulli pickup used in the wafer polishing system of Fig. 1.

Detailed Description of the Drawings

Fig. 1 is a top view of a polishing system that automatically polishes semiconductor wafers or similar workpieces. Polishing system 10 uses robot 20 with Bernoulli pickup 30 to transfer wafers from cassette wafer handling system 40 to six single head wafer polishers 60.

Robot 20 may be a model Maker 100/2 robot which is made commercially available by U.S. Robot of King of Prussia, Pennsylvania. Robot 20 is programed by robot control console 21 to transport wafers to load station 61 and pickup wafers from unload station 62 on the individual polishers. Control console 21 also identifies wafers, ready for pickup by robot 20, in position on a receiver or load station located on wafer handling system 40.

Wafer cassette handling system 40, as illustrated in Fig. 2, is a modified scrubber from Silicon Valley Group of San Jose, California. Scrubber panel 41, cassette holders 42, and brush scrubber 43 are the only part of the original equipment. Scrubber panel 41 was originally mounted to the side of cabinet 45 but was moved to the location shown in Fig. 2. Slurry fail system 48 prevents polishers 60 from trying to polish wafers without slurry which would damage or break the wafers. Fail system 48 consists of fail lights, reset buttons and silence buttons for the primary and final slurries. Also included are pressure switches and interconnects to each polisher computer.

Gauge panel 47 shows pressure settings for brush scrubber 43. Reset panel assembly 46 is used to notify the operator that a cassette located in load assembly 49 is full of wafers. This stops robot 20 from placing additional wafers into the cassette. Once the full cassette is replaced with an empty one a reset button on panel 46 is activated to resume operation. Load assembly 49 is illustrated in greater detail in Fig. 3.

Fig. 3 illustrates load assembly 49 comprising of stainless steel trough 50 with slopping bottom 51 and overflow well 52. Mounted to bottom 51 are guide rods 53. Mounted to guide rods 53 and free to slide the length of rods 53 are handle assemblies 54 and carriage assemblies 55. Wafer cassettes are placed in carriage assemblies 55 for receiving wafers from robot 20. Trough 50 is filled with deionized water (D.I.) up to water level 56 thus submersing carriage assemblies 55. The D.I. water is filtered and recirculated by a pump located below trough 50.

Friction polisher 60 (Fig. 1) uses a servo driven

polishing arm that is mounted to a cabinet. Connected to the polishing arm is a workpiece holder, sometimes referred to as a wafer chuck. Adjacent to the polishing arm is load station 61 which positions the work piece or wafer for pick-up by the polishing arm and attached wafer chuck. Next to the load station is a brush station which automatically cleans the grooves in the wafer chuck prior to picking up the next wafer. Mounted to the cabinet, next to the brush station, is a primary polish station which is used to remove the majority of the rough material. Alongside of the primary polish station is a final polish station used to provide a finished surface to the wafer. At the completion of the polish cycle the polishing arm discharges the polished wafer into unload station 62 which is located next to the final polish station.

Fig. 4 illustrates Bernoulli pickup 30 which is attached to an arm of robot 20 and is used in conjunction with robot 20 to transfer wafers from station to station. A flexible line is connected to pickup 30 by union 31. This line is used for low pressure air. Stainless steel tubing 32 is used to carry vacuum, low volume D.I. water and high volume D.I. water.

In the present form of the invention, one or two cassettes of wafers are placed in cassette holders 42 (Fig. 2) where wafers are automatically fed through brush scrubber 43, which cleans the back side of the wafer. Scrubber 43 then passes the wafer to unload station 44. Incorporated into the bottom of station 44 is a fiber optic sensor which sends a signal to robot 20 that a wafer is ready for pick-up. Robot 20 picks up the wafer using a vacuum and Bernoulli pickup 30 (Fig. 1). Moving in either direction, robot 20 deposits the wafer in the first empty load station 61 of active polishers 60. Only one polisher need be operational for robot 20 to be functional. Once robot 20 has delivered a wafer to load station 61, polisher 60, with its own independent computer system, cleans the backside of the wafer, polishes the frontside of the wafer with the primary and final polish pads, and delivers the wafer to unload station 62.

A wafer that is placed in unload station 62 is suspended in water by jets of water emanating from the bottom of station 62. Also located in the bottom, is a fiber optic sensor which signals robot 20 that a wafer is ready for pickup. The wafer is suspended in unload station 62 to prevent the polished surface, which is facing down, from getting damaged. To prevent scratches, robot 20 is programed to stop pickup 30 below the surface of the water in station 62, just above the wafer. A high pressure stream of water is emitted from pickup 30 for six seconds. Because of the Bernoulli effect, a low pressure area is created between the wafer and pickup 30 which causes the wafer to be drawn

up next to pickup 30. After the six seconds the stream of water is turned off and vacuum is turned on. The wafer is close enough to pickup 30 to make a positive contact.

After retrieving the wafer from unload station 62, robot 20 repositions itself in front of wafer handling system 40 and deposits the wafer into one of the two cassettes in underwater load station 49. Robot 20 loads the cassettes by positioning pickup 30 approximately 1.5 inches directly above the slot to be filled. To release the wafer, the vacuum is turned off and a low pressure stream of water is sent through pickup 30. The wafer slides down pickup 30 into a slot of the cassette. Keeping count of the wafers, robot 20 will load the first cassette until full and then start loading the second cassette. When the first cassette is full of polished wafers, robot 20 notifies the operator through an audio/visual signal on panel assembly 46. Using handle assembly 54 the full cassette is withdrawn from the water and placed in a spin dryer. An empty cassette is placed in carriage assembly 55 and returned to the lowered position in the water. To resume loading of the empty cassette, a reset button on reset panel assembly 46 is activated.

Thus, it is apparent that there has been provided an improved apparatus for polishing semiconductor material. This is accomplished in part with the use of a robot and attached Bernoulli pickup, and a wafer cassette handling system, with an underwater load station.

Claims

1. Apparatus for polishing a semiconductor wafer, including a plurality of wafer polishers (60), each wafer polisher having load (61) and unload (62) stations; a robot arm (20) having attached thereto pick up means for picking up wafers, characterised by:

a wafer cassette handling system (40) having load (49) and unload (44) stations each of the load and unload stations including a container for water so that the wafers can be loaded and unloaded underwater,

said pick up means (30) including means for creating a Bernoulli effect whereby in use a wafer is moved underwater towards the pick up means by a low pressure region created by a high pressure stream of water and the wafer is then picked up so as to transfer wafers from the unload station of the wafer cassette handling system to a wafer polisher and for transferring the wafers from a wafer polisher to the load station of the wafer cassette handling system (40).

2. Apparatus according to claim 1 wherein said

pick up means includes vacuum creation means for holding the wafer to the pick up means once the wafer has been moved towards the pick up means.

3. Apparatus according to claim 1 wherein the Bernoulli effect means comprises means for emitting a high pressure stream of water for a predetermined period.
4. Apparatus according to claim 1, 2 or 3 wherein each of said unload stations of said wafer polishers including a container for water so that the wafers can be unloaded at the unload stations (62) underwater, wherein the pickup means is used to pick up wafers via the Bernoulli effect creating means and to transfer wafers from the unload stations (62) of the polishers to the load station of the wafer handling system (40).
5. Apparatus in accordance with claim 1 wherein the wafer cassette handling system (40) comprises a wafer scrubber (43).
6. Apparatus in accordance with claim 1 wherein the pick up means and robot arm are arranged to secure the wafer from the unload station (62) of the polisher (60) and deposit it into the underwater load station (49).
7. Apparatus in accordance with claim 1 wherein the underwater load station of the wafer cassette handling system (40) comprises:
 - a water trough (50) with a sloping bottom (51);
 - a guide rod (53) mounted to the bottom (51) of the trough (50);
 - a handle assembly (54) mounted to the guide rod (53); and
 - a carriage assembly (55) mounted to the handle assembly (54).
8. Apparatus in accordance with claim 1 wherein the wafer cassette handling system and a plurality of said wafer polishers are arranged in a circular configuration with said robot arm in the central part of the circle for movement between the handling system and wafer polishers.
9. A method for polishing a semiconductor wafer, employing a robot arm having a pick up for moving wafers between load and unload station characterized by the steps of:
 - loading a cassette of wafers onto a wafer handling system (40);
 - cleaning the wafers with a brush scrub (43)



up next to pickup 30. After the six seconds the stream of water is turned off and vacuum is turned on. The wafer is close enough to pickup 30 to make a positive contact.

After retrieving the wafer from unload station 62, robot 20 repositions itself in front of wafer handling system 40 and deposits the wafer into one of the two cassettes in underwater load station 49. Robot 20 loads the cassettes by positioning pickup 30 approximately 1.5 inches directly above the slot to be filled. To release the wafer, the vacuum is turned off and a low pressure stream of water is sent through pickup 30. The wafer slides down pickup 30 into a slot of the cassette. Keeping count of the wafers, robot 20 will load the first cassette until full and then start loading the second cassette. When the first cassette is full of polished wafers, robot 20 notifies the operator through an audio/visual signal on panel assembly 46. Using handle assembly 54 the full cassette is withdrawn from the water and placed in a spin dryer. An empty cassette is placed in carriage assembly 55 and returned to the lowered position in the water. To resume loading of the empty cassette, a reset button on reset panel assembly 46 is activated.

Thus, it is apparent that there has been provided an improved apparatus for polishing semiconductor material. This is accomplished in part with the use of a robot and attached Bernoulli pickup, and a wafer cassette handling system, with an underwater load station.

Claims

1. Apparatus for polishing a semiconductor wafer, including a plurality of wafer polishers (60), each wafer polisher having load (61) and unload (62) stations; a robot arm (20) having attached thereto pick up means for picking up wafers, characterised by:

a wafer cassette handling system (40) having load (49) and unload (44) stations each of the load and unload stations including a container for water so that the wafers can be loaded and unloaded underwater,

said pick up means (30) including means for creating a Bernoulli effect whereby in use a wafer is moved underwater towards the pick up means by a low pressure region created by a high pressure stream of water and the wafer is then picked up so as to transfer wafers from the unload station of the wafer cassette handling system to a wafer polisher and for transferring the wafers from a wafer polisher to the load station of the wafer cassette handling system (40).

2. Apparatus according to claim 1 wherein said

pick up means includes vacuum creation means for holding the wafer to the pick up means once the wafer has been moved towards the pick up means.

3. Apparatus according to claim 1 wherein the Bernoulli effect means comprises means for emitting a high pressure stream of water for a predetermined period.

4. Apparatus according to claim 1, 2 or 3 wherein each of said unload stations of said wafer polishers including a container for water so that the wafers can be unloaded at the unload stations (62) underwater, wherein the pickup means is used to pick up wafers via the Bernoulli effect creating means and to transfer wafers from the unload stations (62) of the polishers to the load station of the wafer handling system (40).

5. Apparatus in accordance with claim 1 wherein the wafer cassette handling system (40) comprises a wafer scrubber (43).

6. Apparatus in accordance with claim 1 wherein the pick up means and robot arm are arranged to secure the wafer from the unload station (62) of the polisher (60) and deposit it into the underwater load station (49).

7. Apparatus in accordance with claim 1 wherein the underwater load station of the wafer cassette handling system (40) comprises:

a water trough (50) with a sloping bottom (51);

a guide rod (53) mounted to the bottom (51) of the trough (50);

a handle assembly (54) mounted to the guide rod (53); and

a carriage assembly (55) mounted to the handle assembly (54).

8. Apparatus in accordance with claim 1 wherein the wafer cassette handling system and a plurality of said wafer polishers are arranged in a circular configuration with said robot arm in the central part of the circle for movement between the handling system and wafer polishers.

9. A method for polishing a semiconductor wafer, employing a robot arm having a pick up for moving wafers between load and unload station characterized by the steps of:

loading a cassette of wafers onto a wafer handling system (40);

cleaning the wafers with a brush scrub (43)



which is located on the wafer handling system (40);

sending the wafers to an unload station on the wafer handling system (40), where the wafers are placed underwater;

obtaining the wafers from the unload station of the wafer handling system (40) with a robot arm (20) using a wafer pickup (30) which provides a high pressure stream of water to create a low pressure region by means of the Bernoulli effect so that a wafer is moved underwater towards the pickup (30);

depositing the wafers into a load station (61) of a wafer polisher (60); and

polishing the wafers on the wafer polisher (60).

Revendications

1. Appareil permettant de polir une pastille semi-conductrice, comportant : plusieurs polisseurs de pastille (60), chaque polisseur de pastille ayant une station de chargement (61) et une station de déchargement (62) ; un bras-robot (20) portant un moyen de prélèvement qui sert à prélever les pastilles,

caractérisé par :

un système (40) de manipulation de cassette de pastilles possédant des postes de chargement (49) et de déchargement (44), chacun des postes de chargement et de déchargement comportant un conteneur destiné à de l'eau, si bien que les pastilles peuvent être chargées et déchargées sous l'eau,

ledit moyen de prélèvement (30) comportant un moyen qui sert à créer un effet Bernoulli, si bien que, en utilisation, une pastille est déplacée sous l'eau en direction du moyen de prélèvement par une région de basse pression qui a été créée par un courant d'eau de haute pression, après quoi la pastille est prélevée, afin de transférer des pastilles depuis la station de déchargement du système de manipulation de cassette de pastilles jusqu'à un polisseur de pastille et pour transférer les pastilles depuis un polisseur de pastille jusqu'à la station de chargement du système (40) de manipulation de cassette de pastilles.

2. Appareil selon la revendication 1, où ledit moyen de prélèvement comporte un moyen de création d'aspiration servant à maintenir la pastille sur le moyen de prélèvement dès que la pastille a été déplacée en direction du moyen de prélèvement.

3. Appareil selon la revendication 1, où le moyen à effet Bernoulli comprend un moyen permet-

tant d'émettre un courant d'eau de haute pression pendant une durée prédéterminée.

4. Appareil selon la revendication 1, 2 ou 3, où chacune desdites stations de déchargement desdits polisseurs de pastille comporte un conteneur destiné à de l'eau de façon que les pastilles puissent être déchargées, dans les stations de déchargement (62), sous l'eau, et où le moyen de prélèvement est utilisé pour prélever des pastilles via le moyen de création de l'effet Bernoulli et pour transférer des pastilles depuis les stations de déchargement (62) des polisseurs jusqu'à la station de chargement du système de manipulation de pastilles (40).

5. Appareil selon la revendication 1, où le système de manipulation de cassette de pastilles (40) comprend un organe (43) de brossage de pastille.

6. Appareil selon la revendication 1, où le moyen de prélèvement et le bras-robot sont conçus de façon à réaliser la fixation de la pastille venant de la station de déchargement (62) du polisseur (60) et à la déposer dans la station de chargement (49) se trouvant sous l'eau.

7. Appareil selon la revendication 1, où la station de chargement sous l'eau du système de manipulation de cassette de pastilles (40) comprend :

une cuve (50) d'eau ayant un fond en pente (51) ;

une tige de guidage (53) montée sur le fond (51) de la cuve (50) ;

un ensemble poignée (54) monté sur la tige de guidage (53) ; et

un ensemble chariot (55) monté sur l'ensemble poignée (54).

8. Appareil selon la revendication 1, où le système de manipulation de cassette de pastilles et une pluralité desdits polisseurs de pastille sont disposés suivant une configuration circulaire comportant, dans sa partie centrale, ledit bras-robot servant à assurer les déplacements entre le système de manipulation et les polisseurs de pastille.

9. Procédé de polissage d'une pastille semi-conductrice, qui emploie un bras-robot doté d'un moyen de prélèvement servant à déplacer des pastilles entre des stations de chargement et de déchargement, caractérisé par les opérations suivantes :

charger une cassette de pastilles sur un



système de manipulation de pastilles (40) ;

nettoyer les pastilles à l'aide d'une brosse (43) qui est disposée sur le système de manipulation de pastilles (40) ;

envoyer les pastilles à une station de déchargement se trouvant sur le système de manipulation de pastilles (40), où les pastilles sont placées sous l'eau ;

obtenir les pastilles de la part de la station de déchargement du système de manipulation de pastilles (40) à l'aide d'un bras-robot (20) utilisant un moyen de prélèvement de pastille (30) qui produit un courant d'eau de haute pression afin de créer une région de basse pression grâce à l'effet Bernoulli, de façon qu'une pastille soit déplacée sous l'eau en direction du moyen de prélèvement (30) ;

déposer les pastilles dans une station de chargement (61) d'un polisseur de pastille (60) ; et

polir les pastilles dans le polisseur de pastille (60).

Patentansprüche

1. Gerät zum Polieren einer Halbleiterscheibe mit einer Mehrzahl von Scheibenpolierern (60), wobei jeder Scheibenpolierer Lade- (61) und Entladestationen (62) besitzt; und einem Roboterarm (20), an den eine Aufnahmevorrichtung zum Aufnehmen von Scheiben befestigt ist, gekennzeichnet durch:
 - ein Scheibenkassettenhandhabungssystem (40) mit Lade- (49) und Entladestationen (44), wobei jede der Lade- und Entladestationen einen Behälter für Wasser umfaßt, so daß die Scheiben unter Wasser geladen und entladen werden können,
 - wobei die Aufnahmevorrichtung (30) eine Vorrichtung zum Erzeugen eines Bernoullieffekts aufweist, wodurch im Betrieb eine Scheibe unter Wasser durch einen Niederdruckbereich, der durch einen Hochdruckwasserstrom erzeugt wird, zur Aufnahmevorrichtung bewegt wird, so daß Scheiben von der Entladestation des Scheibenkassettenhandhabungssystems zu einem Scheibenpolierer bewegt werden und um die Scheiben von einem Scheibenpolierer zur Ladestation des Scheibenkassettenhandhabungssystems (40) zu bewegen.
2. Gerät nach Anspruch 1, wobei die Aufnahmevorrichtung eine Vakuumserzeugungsvorrichtung zum Halten der Scheibe für die Aufnahmevorrichtung umfaßt, sobald die Scheibe zur Aufnahmevorrichtung bewegt worden ist.
3. Gerät nach Anspruch 1, wobei die Bernoullieffekt-

vorrichtung eine Vorrichtung zum Ermitteln eines Hochdruckwasserstroms für einen bestimmten Zeitraum umfaßt.

4. Gerät nach Anspruch 1, 2 oder 3, wobei jede der Entladestationen des Scheibenpolierers einen Wasserbehälter umfaßt, so daß die Scheiben an den Entladestationen (42) unter Wasser entladen werden können, wobei die Aufnahmevorrichtung verwendet wird, um Scheiben über die Bernoullieffektzeugungsvorrichtung aufzunehmen und Scheiben von den Entladestationen (62) des Polierers zu der Ladestation des Scheibenhandhabungssystems (40) zu bewegen.
5. Gerät nach Anspruch 1, wobei das Scheibenkassettenhandhabungssystem (40) einen Scheibenschrubber (43) umfaßt.
6. Gerät nach Anspruch 1, wobei die Aufnahmevorrichtung und der Roboterarm so angeordnet sind, die Scheibe von der Entladestation (62) des Polierers (60) festgehalten wird und in die Unter-Wasser-Entladestation (49) abgelegt wird.
7. Gerät nach Anspruch 1, wobei die Unter-Wasser-Ladestation des Scheibenkassettenhandhabungssystems (40) aufweist:
 - eine Wassermulde (50) mit einem geneigten Boden (51);
 - einen Führungsstab (53), der auf dem Boden (51) der Mulde (50) montiert ist;
 - eine Handhabungsanordnung (54), die auf dem Führungsstab (53) montiert ist; und
 - eine Trägeranordnung (55), die an der Handhabungsanordnung montiert ist.
8. Gerät nach Anspruch 1, wobei das Scheibenkassettenhandhabungssystem und eine Mehrzahl der Scheibenpolierer in einer kreisförmigen Anordnung angeordnet sind, wobei sich der Roboterarm im zentralen Bereich des Kreises befindet für eine Bewegung zwischen dem Handhabungssystem und den Scheibenpolierern.
9. Verfahren zum Polieren einer Halbleiterscheibe unter Verwendung eines Roboterarms mit einem Aufnehmer zum Bewegen von Scheiben zwischen Lade- und Entladestationen, gekennzeichnet durch die Verfahrensschritte:
 - Laden einer Kassette mit Scheiben auf ein Scheibenhandhabungssystem (40);
 - Reinigen der Scheiben mit einem Bürstenschrubber (33), der sich auf dem Scheibenhandhabungssystem (40) befindet;



Senden der Scheiben zu einer Entladestation auf dem Scheibenhandhabungssystem (40), wobei die Scheiben unter Wasser angeordnet werden;

Erhalten der Scheiben von der Entladestation des Scheibenhandhabungssystems (40) mit einem Roboterarm (20), der einen Scheibenaufnehmer (30) verwendet, der einen Hochdruckwasserstrom erzeugt, um mittels des Bernoullieffekts einen Niederdruckbereich zu erzeugen, so daß eine Scheibe unter Wasser zu dem Aufnehmer (30) bewegt wird;

Ablegen der Scheiben in eine Ladestation (61) des Scheibenpolierers (60); und

Polieren der Scheiben auf dem Scheibenpolierer (60).

5

10

15

20

25

30

35

40

45

50

55

8