

AUTOMATED ELECTROPLATING APPARATUS

5 This invention relates to an electroplating apparatus.

In particular but not exclusively this invention relates to an automated electroplating apparatus most suitable for use in electroplating integrated circuits.

Known automated electroplating apparatus usually involve
10 articles to be plated being transported in-line at high speed. The main disadvantages with this system are that the effects of a jam are disastrous and that the apparatus takes up an enormous amount of floor space.

An object of the present invention is to overcome the above disadvantages or difficulties or at least to provide the public with a useful
15 choice.

Accordingly, the present invention consists in an automated electroplating apparatus comprising a plurality of processing cells arranged adjacent each other, at least one processing cell being elongated; gripping means for gripping articles to be plated; and at least one transporting means
20 for transporting the gripping means from cell to cell, wherein the direction of movement of the gripping means from cell to cell is transverse to the longitudinal axis of the elongated processing cell.

The invention will now be described with reference to the accompanying drawings in which :

25 Figure 1 is a schematic top view of the bath
section only of a preferred
embodiment of the apparatus of the

invention showing a suitable arrangement of baths.

Figure 2 is a schematic side view of the bath section of a preferred embodiment of the apparatus of the invention; and a flow diagram indicating the movement of transporters over the baths.

Figure 3 is a side view of a preferred embodiment of a first transporting means of the apparatus of the invention in four different stages of working.

Figure 4 is a perspective view of a preferred flight bar and gripping means for use in the apparatus of the invention.

Figure 5 is an end view of a preferred embodiment of the apparatus of the invention.

Figure 6 is a perspective view of a preferred embodiment of a second transporting means for use in the apparatus of the invention.

Referring to figures 1 and 2, the automated electroplating apparatus of the invention shown generally at 100 comprises a tank 110, and a series of process cells 120 containing the various solutions required to complete an electroplating process. Any suitable arrangement and content of baths may be used as would be clear to those skilled in the art, but shown in figures 1 and 2 is, by way of example, a series of thirty process cells 120 arranged parallel to each other at least one and preferably the majority of which are elongated, a central ten cells of which contain a plating solution.

Figure 1 shows a preferred sequence of events where integrated circuits 140 are loaded at loading bay 01, are prepared for plating through cells 02 to 09, are plated in one of the cells 10-19, are rinsed and dried in cells 26-31 and unloaded at station 32. Process cells 20-25 are for stripping excess plating off flight bars 130 and gripping means 150 (see figure 4). It would seem logical with this type of arrangement for a flow of integrated circuits loaded on flight bars to be placed in each process cell in sequence. However, a problem arises in that the integrated circuits must spend a substantially longer time in the plating process cells than in the other cells. One suitable sequence of events for plating integrated circuits using the apparatus of the invention is as follows:

<u>Stage</u>	<u>Process</u>	<u>Time (secs)</u>	<u>Temp (deg C)</u>
01	Load	21	-
25 02	H ₂ SO ₄	17	70
03	C W Rinse	17	-

	04	C W Rinse	17	-
	05	Anodic H ₂ SO ₄	17	70
	06	C W Rinse	17	-
	07	C W Rinse	17	-
5	08	DI Rinse	17	-
	09	Pre Dip	17	-
	10-19	Tin Plate	200	25
	26	Hot DI Rinse	17	65
	27	Hot DI Rinse	17	65
10	28	Hot DI Rinse	17	65
	29	Air blow off	6	-
	30-31	Hot air Dry	34	90
	32	Unload	21	-
	24-25	Strip	34	-
15	23	C W Rinse	17	-
	22	C W Rinse	17	-
	21	Air blow off	6	-
	20	Hot air dry	17	-
	1	Load	-	90

20 The longer time that the integrated circuits need to spend in the plating cell requires more complex automation than would otherwise be required.

Referring to figure 4, the integrated circuits 140 are preferably held on a flight bar 130 by a gripping means 150. A particularly suitable type of gripping means 150 shown in figure 4 is of the type having a plurality of gripping members 160, each member comprising two opposing arms 170 pivotable about a point 180. In order to avoid damage of the integrated circuits the ends 190 of arms 170 overlap so that

the edge 200 of the integrated circuit gripped by each gripping member is not bent by the force of the arms 170 acting against each other. This type of gripping means is particularly suitable for automatic loading.

Because of the different processes required at different stages of the plating process and the different times required to be spent at each stage, the automated electroplating apparatus of the invention is preferably provided with a transporting means 200 comprising two different types of transporters. The first type shown in figure 3 is an indexing device 220 which has a fixed strokes, so that it picks up at least one flight bar and moves it a set distance to an adjacent position. The second type is a high speed carrier 230 which can pick up a flight bar any predetermined position and move it to any other predetermined position on the apparatus.

A combination of three indexing devices 220 and two carriers 230 provides for a highly efficient automation of the integrated circuit plating process, although other arrangements of indexing devices and carriers are envisaged. The general functioning of the indexing devices 220 and carriers 230 will now be described followed by a description of their roles and interactions in the electroplating apparatus of the invention.

As illustrated in figure 3 the indexing device 220 comprises corresponding arms 240 situated on either side 250 of the tank 110 (figure 1). The sides 250 of the tank 110 have a plurality of recesses 260 for receiving and end 270 of the flight bar 130. Each pair of recesses 260 are on either side 250 of the tank 110 corresponds with a process cell 20. To

avoid the flight bar slipping out of the recesses 260 it is preferable that the ends 270 of the flight bar 130 are shaped to correspond with the shape of the recesses 260, for example, corresponding V-shapes. Recesses 260 are shown in ghost lines in figure 4.

5 Similar recesses 275 are provided on the indexing device. The ends 270 of the flight bar are shaped so as to be able to receive one recess 260 and one recess 270 simultaneously.

 Recesses 270 are positioned on an actuable top portion 280 of arm 240. This portion 280 is preferably actuated by a plurality of
10 hydraulic cylinders 330 which through piston 350, move the top portion 280 from side to side. Top portion 280 is connected by connectors 300, which may be of any suitable configuration, to a fixed bottom portion 290 of arm 240.

 Further hydraulic cylinders 320, through pistons 340, cause
15 the entire arm 240 to move up and down. For strength and stability stabilising rods 360 connected to arm 240 and slidably engaged with rod receivers 370 which are attached to the sides 250 of the tank 110 may be provided.

 Referring now to the sequence of events illustrated in figure
20 4, the indexing device acts to move flight bars in the following fashion :

A. Ends 270 of flight bars are received by recesses 260.

 The integrated circuits 140 are in their respective process cells, one recess 260 corresponding to each cell 120.

- 5 B. The pistons 340 extend from cylinders 320 and push the arm 240 past the recesses 260. While passing recesses 260, recesses 275 pick up the ends 270 of each flight bar 130. The arm 240 is lifted sufficiently high to lift the integrated circuits 140 clear of the process cells 120.
- 10 C. The pistons 350 extend from cylinders 330 to move the top portion 280 of arm 240 to the side by a distance equivalent to the distance from one point on one recess 275 to the same point on an adjacent recess 275. The flight bars are, therefore, now suspended over the process cell 120 adjacent to the process cell they were just removed from.
- 15 D. Pistons 340 retract into cylinders 320 thus lowering the arm back to its position in A. When the recesses 275 pass recesses 260, the ends 270 of the flight bars 130 are received by recesses 260 and the integrated circuits 140 have now moved along the tank by one process cell 120.
- 20 A. Pistons 350 retract into cylinders 330 to prepare the arm 240 to repeat the cycle.

The two arms 240 of the indexing device on either side of the tank 110 obviously must act in unison.

The cycle time for the indexing device may be fixed or variable. In the process sequence listed earlier the cycle time is fixed at 17 seconds as will be later described.

Turning now to the high-speed carrier 230 shown in figure 6. The carrier may be of a number of suitable constructions, but suitably comprises a pair of opposing plates 380 joined and strengthened by rods 390. On the inner surface of each plate 380 is provided an engagement means 410 having a recess 400. In figure 6 the engagement means 410 is shown in a first position on the left hand plate 380 in which it would be when carrying a flight bar between cells; and in a second position on the right hand side in which it would have transferred a carried flight bar to a process cell recess 260. The engagement means 410 is also shown in these two positions in figure 5. It will be understood however that in use the two engagement means 410 must move simultaneously and be in the same position relative to the plates 380 at any one time. The engagement means 410 may be moved up and down hydraulically, pneumatically, via a leadscrew or by any other suitable means. Figure 5 shows a suitable means of mounting the carrier 230 on the tank 110, which comprises a guide rail along which the carrier 230 is driven by way of a drive means 440 which interacts with the gear wheels 420. It will be understood that the carrier 230 may be moved from position to position by any conventional means however.

Turning back now to figure 2, in an embodiment of a suitable arrangement of the apparatus of the invention a first indexing device 220 having eight recesses 275 is positioned corresponding to process cells 02 to 09; a second indexing device 220 having six recesses 275 is positioned corresponding to process cells 20-25; and a third indexing device 220 having seven recesses 275 is positioned corresponding to process cells 26-32.

The top portion 280 of the first and third indexing devices first move from left to right and then right to left. The top portion 280 of the second device moves first from right to left and then left to right.

Two carriers 230 are provided. A first carrier, as illustrated in flow diagram E in figure 4, picks up empty flight bars at cell 20 after they have completed the stripping process in cells 25 to 20. It then carries them to the loading bay 01 where the integrated circuits 140 are loaded into the gripping means by a conventional loading mechanism.

A particularly suitable loading sequence (not shown) comprises the loading of integrated circuits from standard magazines to an indexing bed using a simple vacuum operated pick and place mechanism. The bed consists of moulded, recessed plates which locate the integrated circuits. When a full complement of integrated circuits has been loaded on the indexing bed (usually 16-20), an auto-load vacuum pick-up manifold loads all integrated circuits simultaneously to individual gripping members mounted on the flight bar.

The flight bars are then moved to cell 02 by the first carrier 230 and are moved along to cell 09 by the first indexing device. At cell 09 they are picked up by the first carrier and put into an available plating cell 10-19. The first carrier then proceeds to pick up a further unloaded flight bar from cell 20 and to take it to loading bay 01 for loading.

After the plating cell stage is completed, the second carrier picks up a flight bar and carries it to process cell 26 for rinsing and drying. Movement through cells 26-32 is taken care of by the third indexing device. Once the flight bars are unloaded at unloading bay 32, they are again picked up by the second carrier and taken to cell 25 for stripping of plating material built up on the gripping means. Movement of the unloaded flight bars through cells 25 to 20 is taken care of by the second indexing device. Once stripping is completed the flight bars are ready to be reloaded and are picked up by the first carrier at cell 20 and taken for loading.

Cells containing the same substance eg. 03 and 04, 06 and 07, 10-19 (in particular), 22 and 23, and 26 to 28 may in fact be only one cell with two (or more) recess positions, so that the integrated circuits remain in those solutions for two (or more) cycles of the indexing device, that is, twice as long (or more) as in those cells with only one recess position.

To allow good plating distribution on incompletely loaded flight bars, it is preferable that end shields be automatically moved into position when required.

To protect the bottom edge of the integrated circuits from over plating it is preferable that a floating cathode shield such as that disclosed in U.S. Patent No. 4879007, which is incorporated herein by reference, be used in the plating cells. These shields are buoyant but
5 submergible under the weight or the downward pressure or both of the articles to be plated and the flight bar. This makes them particularly suitable for use in automated processes. The shields may be used with or without being slidably mounted at each end to a process cell. Other types of cathode shield may also be useful, such as a cathode shield which also
10 comprises buoyancy activated clamps which clamp the ends of articles to be plated as they are submerged.

The major advantage of the apparatus of the invention is that it utilises up to 60% less floor space than the previously known apparatus without compromising processing efficiency. A further advantage is that
15 the damaging effects of a jam are significantly reduced.

The above describes a preferred embodiment of the invention, variations and modifications in which may be made without departing from the scope of the invention as defined in the accompanying claims.

20 For example, any suitable type of gripping means or gripping members may be used depending upon the articles to be plated.

The apparatus could of course be arranged in a number of different ways, and the arrangement described above gives an example only of a suitable arrangement for a specific process. Other process may

require different arrangements of the process cells and transporting means.

It is envisaged that an arrangement in which no carrier is provided and an indexing device or a plurality of indexing devices or the like merely moves the flight bars incrementally along the tank as required and some other
5 conveyer would return flight bars for reloading. Returning the flight bars for reloading may even be done manually.

It will be understood by those skilled in the art to which this invention relates that any suitable type of process cells, transporting means, gripping means, loading means etc might be utilised which will allow the
10 gripping means to be moved from cell to cell in a direction transverse to the longitudinal axis of the elongated processing cell.

CLAIMS :

1. An automated electroplating apparatus comprising a plurality of processing cells arranged adjacent each other, at least one processing cell
5 being elongated; gripping means for gripping articles to be plated; and at least one transporting means for transporting the gripping means from cell to cell, wherein the direction of movement of the gripping means from cell to cell is transverse to the longitudinal axis of the elongated processing cell.
2. An automated electroplating apparatus as claimed in claim 1,
10 further comprising a support means to support the gripping means at each cell.
3. An automated electroplating apparatus as claimed in claim 1 or claim 2, wherein the gripping means comprises a plurality of gripping members attached to a flight bar.
- 15 4. An automated electroplating apparatus as claimed in claim 3, wherein the gripping means comprises a single row of gripping members.
5. An automated electroplating apparatus as claimed in claim 3 or claim 4, wherein the gripping members are pivotable.
6. An automated electroplating apparatus as claimed in any one of
20 claims 3-5, wherein each gripping member comprises two opposing arms, each having a gripping surface, the gripping surfaces being offset relative to each other, at least a portion of the gripping surfaces overlapping.



7. An automated electroplating apparatus as claimed in any one of claims 1-6, wherein the gripping means grips the top of an article to be plated.
8. An automated electroplating apparatus as claimed in any one of claims 1-7, wherein the transporting means comprises a plurality of transporters.
9. An automated electroplating apparatus as claimed in claim 8, wherein at least one transporter acts only to move gripping members a fixed distance.
10. An automated electroplating apparatus as claimed in claim 8 or claim 9, wherein at least one transporter acts to move gripping members variable distances.
11. An automated electroplating apparatus as claimed in any one of claims 1-10, further comprising a cathode shielding device to prevent over plating of the edges of the articles to be plated.
12. An automated electroplating apparatus as claimed in claim 11, wherein the cathode shielding device is buoyant but submergible under the weight or downwards pressure or both of the gripping means and articles to be plated.
13. An automated electroplating apparatus as claimed in any one of claims 1-12, wherein at least 25% of the process cells are elongated.
14. An automated electroplating apparatus as claimed in any one of claims 1-13, wherein at least 50% of the process cells are elongated.



15. An automated electroplating apparatus as claimed in any one of claims 1-14, wherein at least 75% of the process cells are elongated.
16. An automated electroplating apparatus as claimed in any one of claims 1-15, wherein all the process cells are elongated.
- 5 17. An automated electroplating a substantially as herein described with reference to the accompanying drawings.

