



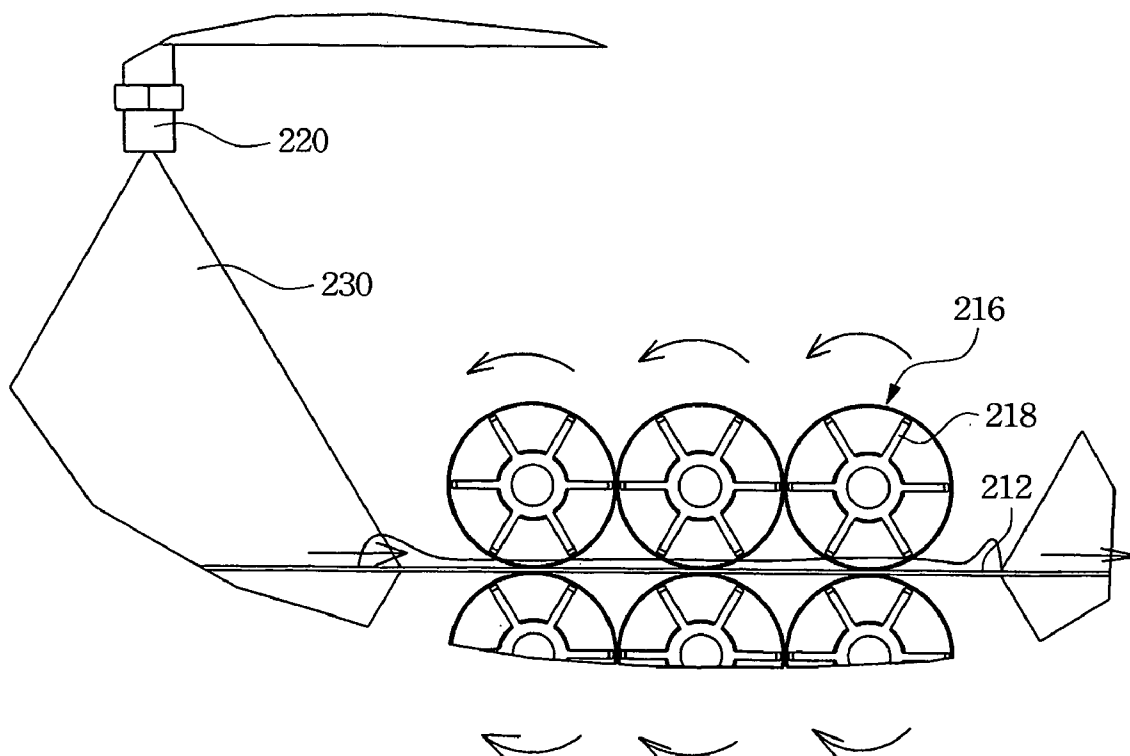
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(19) **United States**(12) **Patent Application Publication**
Chang(10) **Pub. No.: US 2007/0221330 A1**(43) **Pub. Date: Sep. 27, 2007**(54) **AGITATED WET PROCESS MACHINE****Publication Classification**(76) Inventor: **Shih-Chang Chang, Tao Yuan**
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ELLICOTT CITY, MD 21043(52) **U.S. Cl.** **156/345.17; 156/345.2**(57) **ABSTRACT**

An agitated wet process machine comprises a delivery system and many jets. The delivery system comprises a delivery belt and many rollers, wherein the rollers on the upper side or the lower side of the delivery belt are used to deliver workpieces. Many blades are added on each of the rollers to agitate a chemical solution. The jets above and below the delivery belt are used to spray or supply the chemical solution to the workpieces.

(21) Appl. No.: **11/583,820**(22) Filed: **Oct. 20, 2006**(30) **Foreign Application Priority Data**

Mar. 22, 2006 (TW) 95109941



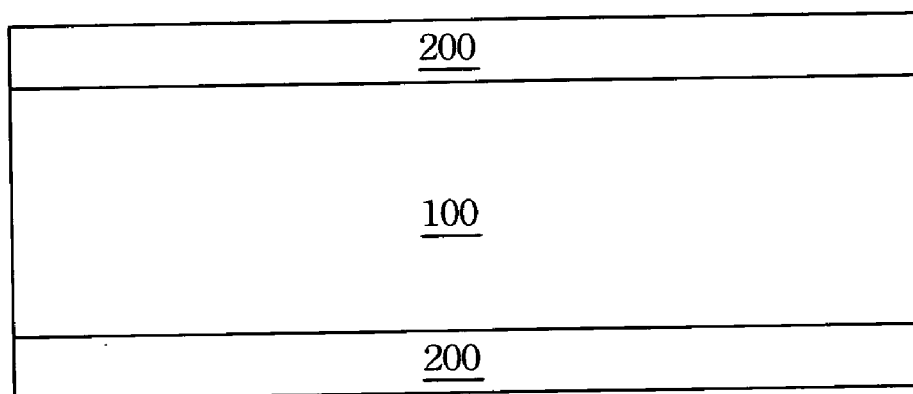


Fig. 1
(PRIOR ART)

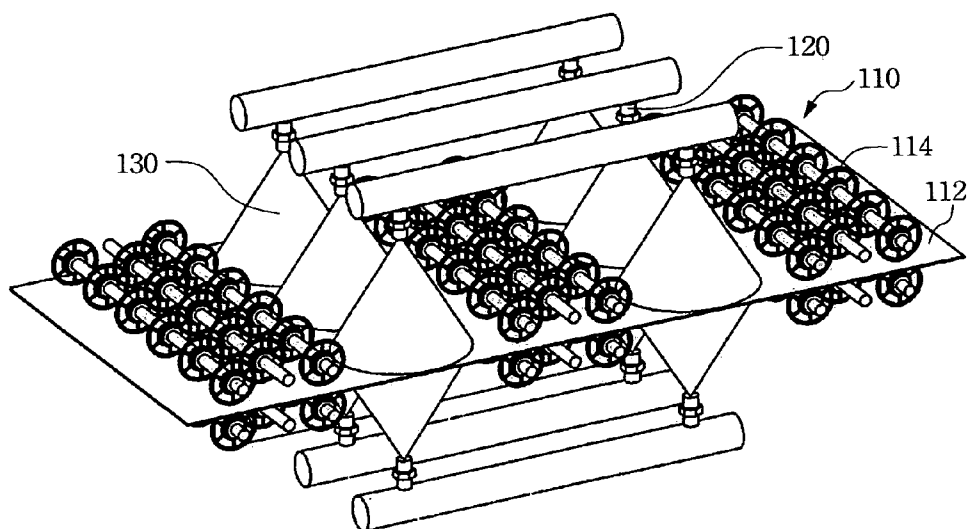


Fig. 2
(PRIOR ART)

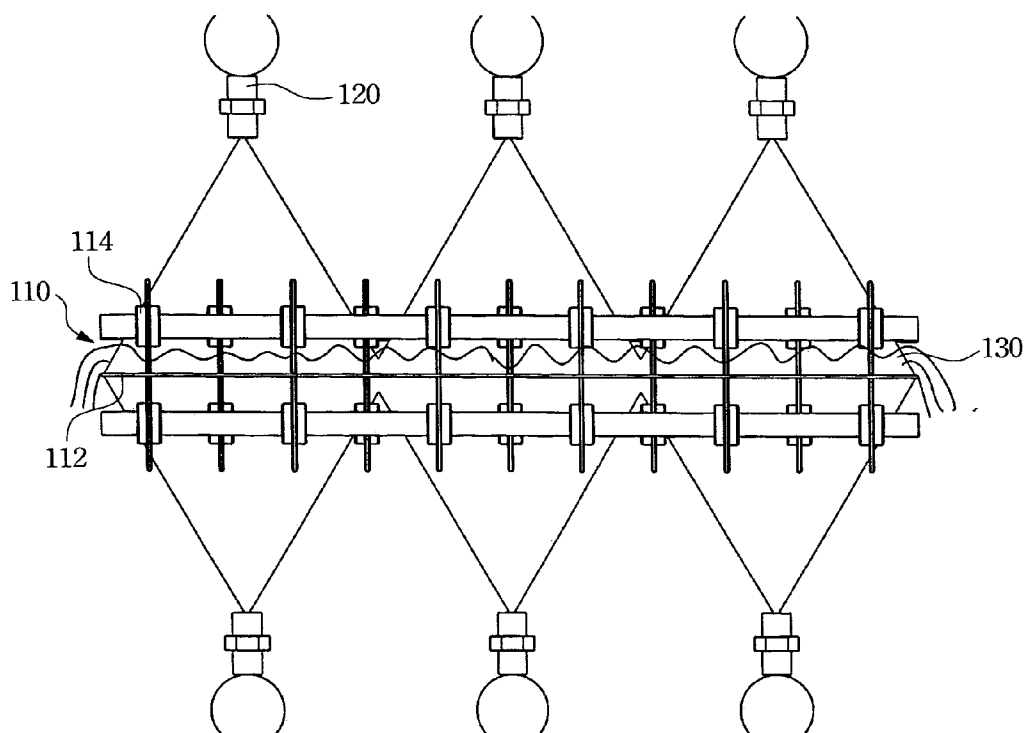


Fig. 3
(PRIOR ART)

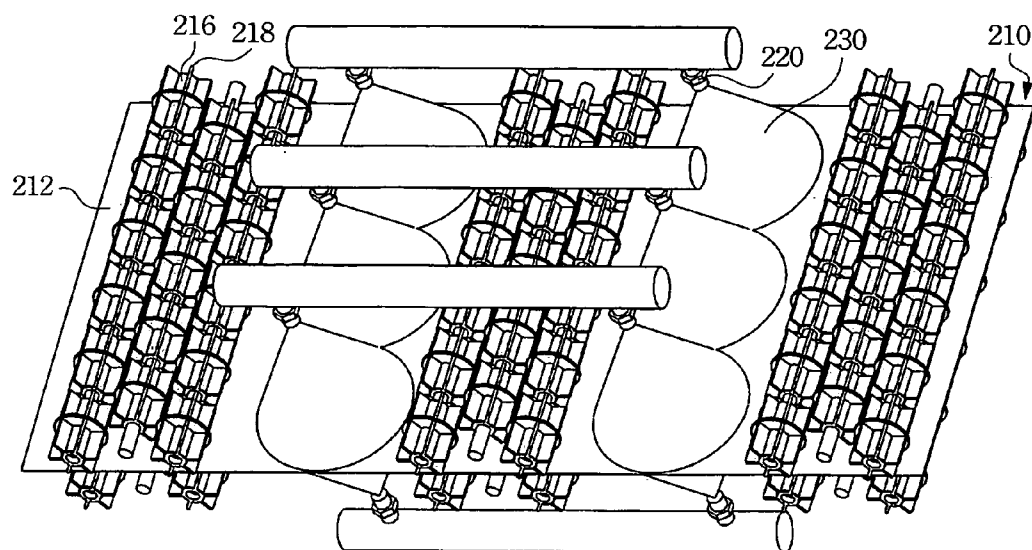


Fig. 4

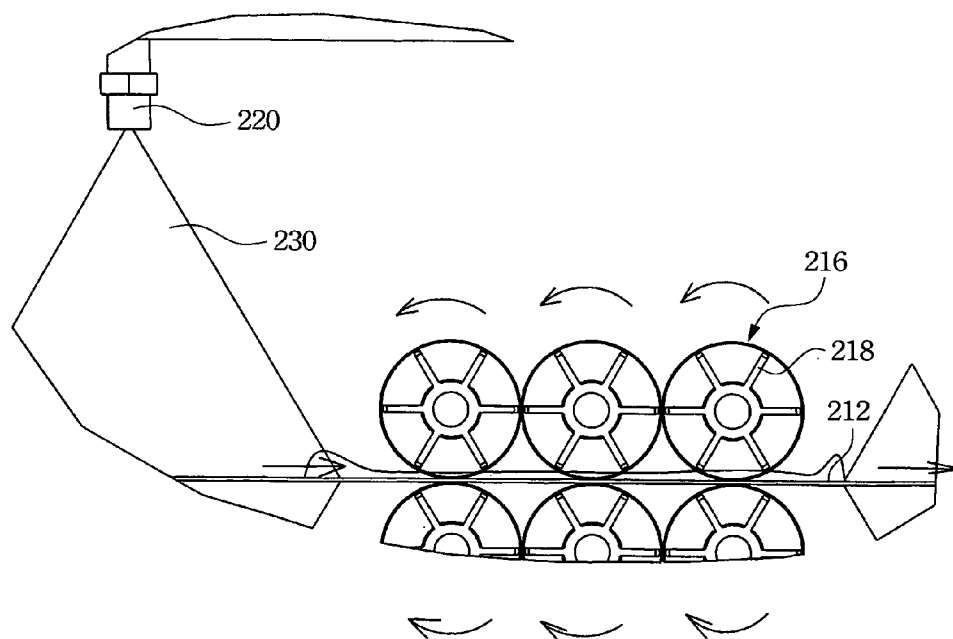


Fig. 5

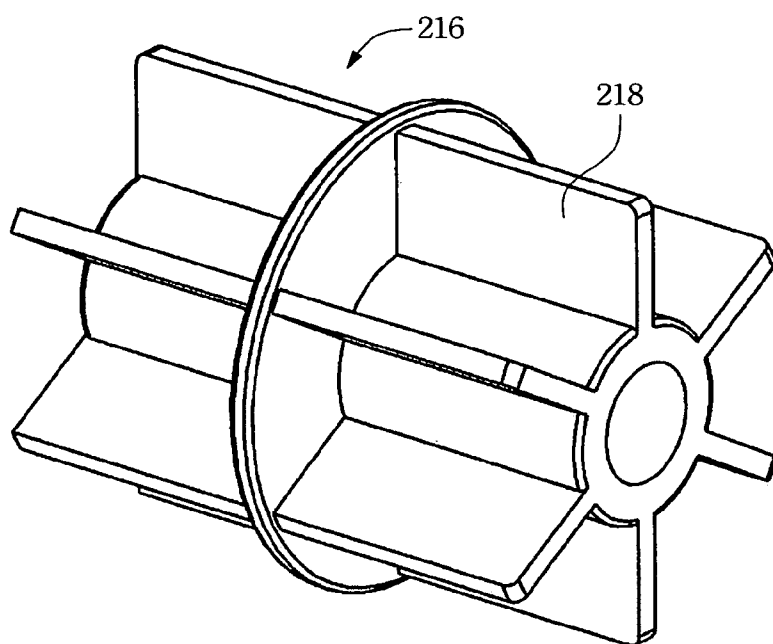


Fig. 6

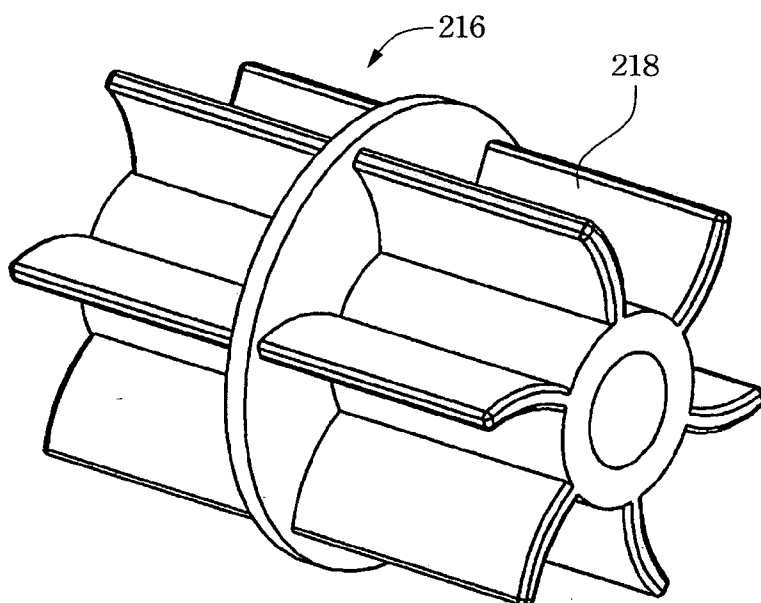


Fig. 7

AGITATED WET PROCESS MACHINE

RELATED APPLICATIONS

[0001] The present application is based on, and claims priority from, Taiwan Application Serial Number 95109941, filed Mar. 22, 2006, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

[0002] 1. Field of Invention

[0003] The present invention relates to a machine for wet process. More particularly, the present invention relates to an agitated wet process machine.

[0004] 2. Description of Related Art

[0005] Because of the rapid development in high technology and an increased demand for light and easy to use products, light, thin, small and portable electronic products are becoming the most popular products. Because electronic products are getting smaller, the internal volume of electronic products containing printed the circuit boards is also getting smaller. Therefore, there is a need to develop high-density printed circuit boards containing more circuits in a smaller area.

[0006] Line widths and line spaces on general printed circuit boards are about 4-6 mil. (1 mil.=0.025 mm). On high-density printed circuit boards, line widths and line spaces are about 1 mil. Because the line widths and the line spaces on high-density printed circuit boards are narrower than those on general printed circuit boards, the process quality requirement for high-density printed circuit boards is stricter than that for general printed circuit boards.

[0007] In the printed circuit wet processes, both the developing process and the etching process are important for the line widths and the line spaces of printed circuit boards. However, there is a serious water-retention problem, which limits recent manufacturing processes to manufacture high-density printed circuit boards which have narrower line widths and line spaces than general printed circuit boards.

SUMMARY

[0008] It is therefore an aspect of the present invention to provide an agitated wet process machine, which can eliminate the problem of water-retention in the wet process and thus increase the quality of wet processes, including the developing and etching processes.

[0009] In accordance with the foregoing and other aspects of the present invention, an agitated wet process machine is provided. The agitated wet process machine comprises a delivery system and many jets. The delivery system comprises a delivery belt, many rollers and many blades. The rollers are located on the upper side or the lower side of the delivery belt to deliver workpieces on the delivery belt. The blades are on each roller to agitate a chemical solution. The jets are located above and below the delivery belt and are used to spray or supply the chemical solution to the workpieces.

[0010] In accordance with the foregoing and other aspects of the present invention, an agitated wet process machine is provided. The agitated wet process machine comprises a delivery system and many jets. The delivery system comprises a delivery belt, many rollers and many blades. The rollers are located on the upper side or the lower side of the delivery belt to deliver workpieces on the delivery belt. The

blades are on each roller to agitate a chemical solution. There is a distance between the blades and fringes of the rollers. The jets are located above and below the delivery belt and are used to spray or supply the chemical solution to the workpieces.

[0011] In accordance with the foregoing and other aspects of the present invention, a process employing the agitated wet process machine is provided. Firstly, many workpieces below many jets are delivered. Then, a chemical solution is sprayed to the workpieces to process them. Finally, the chemical solution is agitated to increase the processing efficiency.

[0012] In conclusion, the invention adds blades on the rollers in the traditional wet process machine. When the roller rotates, the blades on the rollers can bring a fresh chemical solution into the processing region and bring the processed chemical solution out of the processing region. The blades on the rollers thus can increase the mobility of the chemical solution. The chemical solution no longer accumulates around the rollers. Therefore, the invention not only solves the problem of water-retention but also increases the quality and the efficiency of the wet process. The number of the blades, the shape of the blades, the distance between the blades and fringes of the rollers and the position of the jets in the invention all can be adjusted to meet any special requirements for different processes. Moreover, the invention not only can be employed in the developing and etching processes of printed circuit boards to increase the manufacturing precision but can also be employed in other chemical processes which have requirements to increase the process precision.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. In the drawings,

[0014] FIG. 1 is a cross-sectional side view of a printed circuit board;

[0015] FIG. 2 is a structural diagram of traditional wet process machine;

[0016] FIG. 3 is a diagram to indicate the chemical solution-discharging route;

[0017] FIG. 4 is a structural diagram of an agitated wet process machine according to one preferred embodiment of this invention;

[0018] FIG. 5 is a diagram to explain the function and movement of the rollers;

[0019] FIG. 6 is a structural diagram of a roller according to one preferred embodiment of this invention; and

[0020] FIG. 7 is a structural diagram of a roller according to another preferred embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] In the following, the manufacturing process of printed circuit boards is used as an example to illustrate the concept of the invention. However, the invention is not limited to the process of printed circuit boards. In reality, because of the development and progress of high technology, a wet process is employed from the traditional industry

of printed circuit boards to fields of other industries. Now, wet processes are successfully employed in the industries of semiconductor, liquid crystal display panel and plasma display. Therefore, the invention can be employed in these industries to increase their process quality.

[0022] The manufacturing processes of printed circuit boards can be divided into three types, mechanical process, wet process and image transfer process. Among these processes, the wet process is the process that uses chemical solutions. Wet processes comprise electroplating, developing, etching, film stripping, washing, degreasing, cleaning with ultrasonic, de-smearing and chemical roughing etc. Among these processes, the developing and etching processes have critical influence on line widths and line spaces of printed circuit boards. The invention not only increases the quality of the developing and etching processes to manufacture high-density printed circuit boards but can also improve the quality of other wet process-related manufacturing processes.

[0023] FIG. 1 is a cross-sectional side view of a printed circuit board. A circuit is manufactured on the substrate with the developing and etching processes. In FIG. 1, the substrate comprises an insulating layer 100 and two copper films 200 on either side. The material of the insulating layer 100 is generally resin and glass fiber. The thickness of the copper film 200 is 5 μm , 9 μm , 12 μm , 18 μm , 35 μm , 50 μm and 70 μm . A 35 μm thickness is most commonly used.

[0024] In the processes of printed circuit boards, a layer of either positive or negative photoresist is initially formed on the copper films of the substrate. A predefined pattern is transferred to the photoresist by a light-exposing process. Then, the exposed region of the positive photoresist or the unexposed region of the negative photoresist is dissolved in a developing solution during a developing process. The copper uncovered by the photoresist is etched in an etching process to form circuits on the substrate. Finally, the photoresist is removed by a film stripping process.

[0025] Among the above processes, the developing and etching processes are critical in the manufacturing printed circuit boards. Good developing and etching processes can correctly transfer each subtle feature of a predefined circuit pattern to copper films of a substrate to form circuits. Therefore, some printed circuit boards such as high-density printed circuit boards, which have higher and stricter demands for line widths and line spaces, often need good developing and etching technologies.

[0026] However, there is a serious water-retention problem in recent wet processes. This problem affects the quality of the etching and developing processes and limits the line widths and the line spaces from becoming narrower to satisfy the requirement of high-density printed circuit boards.

[0027] In the following, a diagram will be used to illustrate the water-retention problem. FIG. 2 is a structural diagram of traditional wet process machine. The wet process machine in FIG. 2 comprises a delivery system 110 and many jets 120. The delivery system 110 is used to deliver the printed circuit boards, which need to be processed. The jets 120 are used to spray a chemical solution 130. In the developing and etching processes, the chemical solution 130 generally is a developing solution or an etching solution. The delivery system 110 comprises a delivery belt 112 and many rollers 114. The rollers 114 located on the upper side or the lower side of the delivery belt 112, deliver the printed circuit

boards on the delivery belt 112. The jets 120 are located above and below the delivery belt 112 and eject the high-pressure chemical solution 130 to the printed circuit boards. The striking power of the high-pressure chemical solution 130 and the reactivity of the chemical solution 130 with the printed circuit boards are used carry out some processes such as developing and etching the printed circuit boards. Because the pressure ejected by the jets 120 is so high, with the exception of some portion of the chemical solution 130 being sprayed to the printed circuit boards, a large portion of chemical solution 130 enters regions where the rollers 114 exit. Because of the pushing effect between the front jets and the rear jets, surface tension of the liquid and obstacles formed by the cross-arrangement of the rollers 114, the chemical solution 130 in the roller-exiting regions hardly flows. Therefore, lots of chemical solution 130 accumulates in these regions. This accumulation phenomenon is called water-retention.

[0028] In FIG. 3, the chemical solution 130 accumulated in those regions can be discharged from two sides of the delivery belt 112. However, that would cause the flow rate of the chemical solution 130 in the middle to be different from that of the chemical solution 130 at the two sides. Different flow rates would result in different etching rates. Therefore, printed circuit boards in the middle would not be etched enough, but printed circuit boards on either side would be over etched. In the past, this problem is solved by arranging the jets to be parallel to the delivery direction of the delivery belt and to make the pressure of the jets in the middle higher than that of the jets on the two sides. The difference in pressure alters the etching rate. The higher the pressure is, the faster the etching rate is. Therefore, the difference in pressure of the jets can compensate for the difference in the etching rates resulting from different flow rates between the middle region and the side regions. This method can reduce the influence of water-retention problem on printed circuit boards, but cannot totally overcome it. Therefore, this method is only suitable for processing printed circuit boards with onboard line widths wider than 2 mil. This method can't be used to process high-density circuit boards with onboard line widths and line spaces narrower than 2 mil. The invention uses the concept of mass transfer in chemical engineering and provides an agitated wet process machine. The invention adds blades on each roller of the agitated wet process machine to agitate the chemical solution and increase its flow rate. By adjusting the number of the blades, the shape of the blades, the distance between the blades and fringes of the rollers and the position of the jets, equal etching rates between the middle region and the side regions can be achieved. The agitated machine of the invention not only successfully solves the water-retention problem but also increases the quality and the efficiency of the etching and developing processes.

[0029] FIG. 4 is a structural diagram of an agitated wet process machine according to one preferred embodiment of this invention. In FIG. 4, the agitated wet process machine comprises a delivery system 210 and many jets 220. The delivery system comprises a delivery belt 212 and many rollers 216. Because each roller 216 has many blades 218 thereon, the rollers not only drive the delivery belt 212 forward but also agitate the chemical solution 230 to increase its flow rate. There is a distance between the blades 218 and fringes of the rollers 216. The distance is adjustable to achieve a better agitating effect. The rollers 230 can

efficiently increase the flow rate of chemical solution **230** in the middle region and thus can solve the water-retention problem caused by unequal flow rates between the middle region and the side regions. Therefore, the quality of the etching and developing processes can be increased. The agitated machine of the invention can be employed to process high-density printed circuit boards, which have line widths narrower than 2 mil.

[0030] In the traditional machine in FIG. 2, the jets **120** can't be installed above the rollers **114** because the rollers **114** will cause an unequal chemical solution **130** impact power and further influence the processing quality. However, the agitated wet process machine of the current invention can selectively install jets with large angles, low pressures and high flow volumes above the rollers without the problem of unequal impact power. These jets can provide a fresh chemical solution to increase processing rate.

[0031] FIG. 5 is a diagram to explain the function and movement of the rollers. When the rollers **216** rotates, the blades **218** on the rollers **216** can bring a fresh chemical solution **230** into the processing region and bring the processed chemical solution **230** out of processing region.

[0032] In the following, a mass transfer formula will be used to illustrate the influence of the rollers on the flow of the chemical solution. The chemical solution agitated by the blades of the rollers can be viewed as an open channel flow. The mass transfer formula of the chemical solution is expressed in the following:

$$Sh_{AB} = 0.027 Re^{0.8} Sc^{1/3} \text{ (turbulent flow)} \quad \text{Eq. (1)}$$

$$Sh_{AB} = \frac{k_c D_c}{D_{AB}} = \text{Sherwood number} \quad \text{Eq. (2)}$$

$$Re = \frac{D_c u_b}{\mu} = \text{Reynolds number} \quad \text{Eq. (3)}$$

$$Sc = \frac{\mu}{D_{AB} \rho} \quad \text{Eq. (4)}$$

[0033] In Eq. (1)-(4), k_c is a mass transfer coefficient; D_c is an equal diameter; D_{AB} is a diffusion coefficient; u_b is an average flow rate; ρ is a liquid density; μ is a liquid viscous coefficient. When the rollers rotate, the blades on the rollers will agitate the chemical solution to increase the axial flow rate of the chemical solution. Based on Eq. (2) and Eq. (3), an increase of the average flow rate (u_b) will result in an increase of the Reynolds number and Sherwood number. Therefore, the mass transfer coefficient (k_c) increases.

$$N_A = k_c (C_{A\infty} - C_A^*) \quad \text{Eq. (5)}$$

[0034] In Eq. (5), N_A is a mass transfer value; $C_{A\infty}$ is the concentration of the liquid in the bulk phase; C_A^* is the concentration of the liquid at the processed surfaces of workpieces. Eq. (5) indicates that an increase in the mass transfer coefficient (k_c) will result in an increase of the mass transfer value (N_A). Therefore, the effective ingredients of the chemical solution can reach the processed surfaces of the workpieces easily and thus the processing efficiency of the chemical solution increases.

[0035] FIG. 6 is a structural diagram of a roller according to one preferred embodiment of this invention. In the preferred embodiment, the number of the blades **218** on each of the rollers **216** is six. The surface of the blades **218** is flat.

In another embodiment, the number of the blades, the shape of the blades and the distance between the blades and fringes of the rollers can be adjusted according to the actual requirement for optimizing the processing quality. FIG. 7 is a structural diagram of a roller according to another preferred embodiment of this invention. In FIG. 7, the surfaces of the blades **218** are curved to increase the ability to agitate the chemical solution.

[0036] In conclusion, the agitated wet process machine of the invention adds blades on the rollers to increase the mass transfer of the chemical solution. Moreover, four design parameters can be adjusted to achieve an optimum wet process quality. Therefore, printed circuit boards processed by the agitated machine has narrower line widths and line spaces and the agitated machine can be used to process high-density printed circuit boards. The following are the four design parameters that can be adjusted.

[0037] (1) The agitated wet process machine of the invention can selectively install jets with large angles, low pressures and high flow volumes above the rollers.

[0038] (2) The number of the blades on each of the rollers can be changed.

[0039] (3) The shape of the blades on the rollers can be changed.

[0040] (4) The distance between the blades and fringes of the rollers can be changed.

[0041] Accordingly, the present invention has the following advantages.

[0042] (1) The agitated wet process machine of the invention can eliminate the wet process water-retention problem and thus increase the wet process quality, including the developing and etching processes. Therefore, the agitated machine can be used to process high-density printed circuit boards.

[0043] (2) The agitated wet process machine of the invention can increase the processing efficiency of the chemical solution.

[0044] The preferred embodiments of the present invention described above should not be regarded as limitations to the present invention. It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the scope or spirit of the invention. The scope of the present invention is as defined in the appended claims.

What is claimed is:

1. An agitated wet process machine, comprising:

A delivery system, comprising:

a delivery belt; and

a plurality of rollers located on the upper side or the lower side of the delivery belt to deliver workpieces on the delivery belt; and

a plurality of blades on each of the rollers to agitate a chemical solution; and

a plurality of jets located above and below the delivery belt and used to spray or supply the chemical solution to the workpieces.

2. The machine of claim 1, wherein the number of the blades on each of the roller is six.

3. The machine of claim 1, wherein the surface of the blades is flat.

4. The machine of claim 1, wherein the surface of the blades is curved.

5. The machine of claim 1, wherein there is a distance between the blades and fringes of the rollers.

6. The machine of claim 1, wherein the jets are located between the rollers.

7. The machine of claim 6, wherein the jets are located above the rollers.

8. An agitated wet process machine, comprising:

A delivery system, comprising:

a delivery belt; and

a plurality of rollers located on the upper side or the lower side of the delivery belt to deliver workpieces on the delivery belt; and

a plurality of blades on each of the rollers to agitate a chemical solution, wherein there is a distance between the blades and fringes of the rollers; and

a plurality of jets located above and below the delivery belt and used to spray or supply the chemical solution to the workpieces.

9. The machine of claim 8, wherein the jets are located between the rollers.

10. A process employing the machine of claim 1, comprising:

delivering a plurality of workpieces below a plurality of jets;

spraying a chemical solution on the workpieces to process the workpieces; and

agitating the chemical solution to increase the processing efficiency.

* * * * *