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50. Internationales Wissenschaftliches Kolloquium
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Fine Processing Method and Device by Chemical Erosion

ABSTRACT

The paper deals with the advantages of the spray etching method and presents the construction data of an original laboratory etching equipment which performs optimal working parameters: chemical attack from both sides of the part and differential chemical attack, flow and temperature controlling of the etching solution, low lateral etching, high productivity and great fineness of processing. There are also presented the results of the tests performed by the authors in order to execute double etched screens used in SMD technology. The obtained results confirm the constructive solution, chosen for the equipment design.

INTRODUCTION

Chemical erosion has a wide practicability, especially in micro-techniques, due to its capacity of executing very fine structures in small depths or in thin layers, as also due to the insensitiveness of obtained precision relative to the structure, mechanical, magnetic properties etc. of the material being processed. This feature allows achieving a large type of thin sheet parts (replacing successfully punching) and the most complex structures from the electronic industry. As well, this processing method is one of the few methods where the complexity of the components is not reflecting in costs [1, 2].

Etching equipment and techniques have developed on the following basis: immersion etching, barbotage, blade stirring and spray etching. The spraying method is most widely used, although expensive, but it ensures optimal performances: high etching factor (ratio of processing depth to lateral etching), short attack time, processing conditions that allow strong impact with the surface of the part, refreshing of the solution, and high oxidation power of the same [3].

The performances of etching process are appreciated after some accepted criteria, which are: the dimension tolerance, lateral etching, resolution and accuracy of part edge.

AUTOMATIC ETCHING INSTALLATION

The automatic etching installation, which scheme is shown in fig. 1, was designed and manufactured by the authors at the Department of Precision Engineering from the "Politehnica" University of Bucharest. The installation is composed of the following elements: the PVC vat 1, in which the attack solution 4 is found up to the level indicator; two quartz glass pipes 5, calked with rubber packing gaskets fixed with caps; the sliding frames 6, mounted on the side walls of the vat; the articulated parallelogram mechanism 7 and the crank arm mechanism 10 that generates the tilting-in-opposition movement of the pipes with nozzles was designed compactly, allowing the jets to "sweep" the whole etching surface; the electronic unit 9 of the encoder 8; the d.c. motor 11; the electronic unit of the d.c. motor 12; the filter 13; the electronic unit 14 of the centrifugal pump 15; the electronic unit 16 of the proportional throttle valve 17; the turbine flow sensor 18; the warming thermostatic system 19 and its electronic unit 20; the temperature sensor 21 and its electronic unit 22; the data acquisition board 23 and the PC 24. The part to be etched 2, selectively protected using the photoresist masks 3, is put between the sliding frames 6 and between the quartz glass pipes 5.

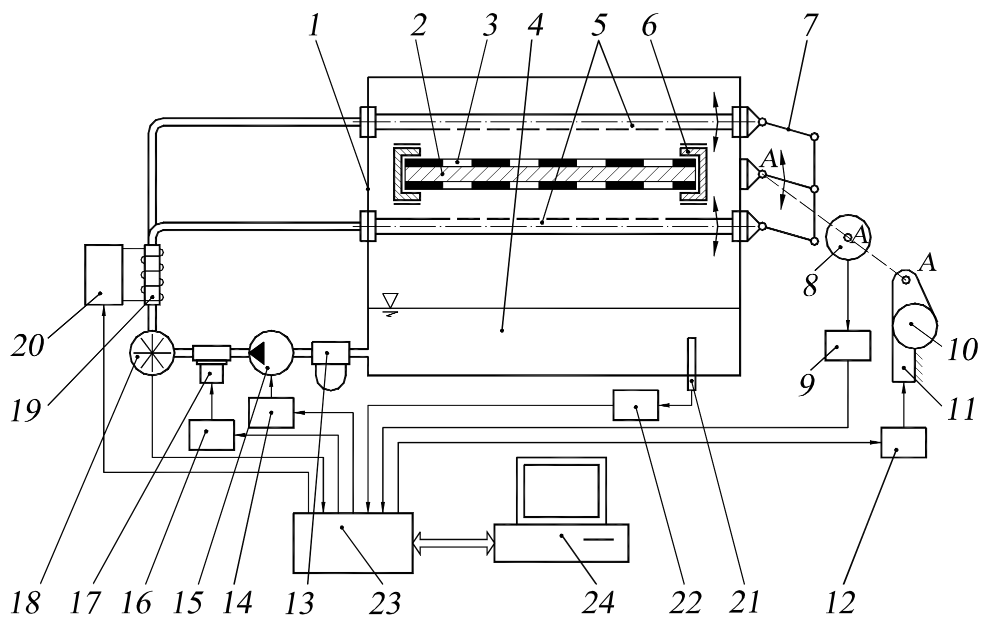


Fig. 1 The scheme of the laboratory etching installation

The installation allows modifying the *flow* and the *temperature* of the etching solution and the *angular velocity* of the quartz glass pipes in order to obtain optimal values of these parameters, according to the material, thickness, geometrical configuration and precision of the part, by means of the centrifugal pump, the proportional throttle valve, the turbine flow sensor, the warming thermostatic system, the temperature sensor, the d.c. motor, and the encoder, which are connected via the data acquisition board to the PC.

The mechanism that generates the tilting-in-opposition movement of the pipes with nozzles was designed compactly, allowing the jets to “sweep” the whole etching surface. The rotation speed of the crank arm mechanism is adjustable by varying the rotation speed of the d.c. motor. The kinematic analysis of the tilting mechanism points out the uniformity of movement of the pipes with nozzles. These constructive features, as also the big number of nozzles, ensure the uniformity of etching on the whole surface of the part [4]. *Simultaneous etching from both sides* is possible for the part set in horizontal position. One-sided etching (from below) is applied when high accuracy geometry is needed.

Holes are drilled in the glass pipes, forming 21 nozzles with a diameter of 2 mm on each pipe. The distance between two nozzles is constant and equal to 15 mm. The etching solution is spraying through the nozzles on the active sides of the part.

The attack solution is taken from the vat by the centrifugal pump, ensuring a maximum flow of about 0.5 l/s. The pump is equipped with an a.c. motor with a rotation speed of 2800 rot/min. In order to maintain the quality of the solution, a filter is mounted on the circulating pipe. The proportional throttle valve, controlled by a stepping motor, allows flow adjusting. The flow is measured using a tangential turbine sensor with standard measuring range of 3÷90 l/h.

The warming thermostatic system uses a Cu-Ni electric resistance winded on a quartz tube, in which the attack agent is circulated. The temperature of the attack solution is measured using a temperature sensor of type thermal resistance Pt 100, with the sensor diameter of 3 mm and the measuring range of -50÷250˚C.

The proportional throttle valve, the flow sensor, the warming thermostatic system and the temperature sensor are connected via the data acquisition board to the PC, allowing flow and temperature modification of the etching agent.

The data acquisition board type AX 5411 is a multifunctional board with analog and digital I/O. In order to ease the development of software applications, the board was delivered with a specific driver, containing libraries with the most used functions involved in data acquisition and processing.

The logical diagram of the application program, which manages the automatic etching installation, is given in fig. 2.

The item 1 shows the characteristic parameters of the part: material, thickness, geometrical configuration, precision.

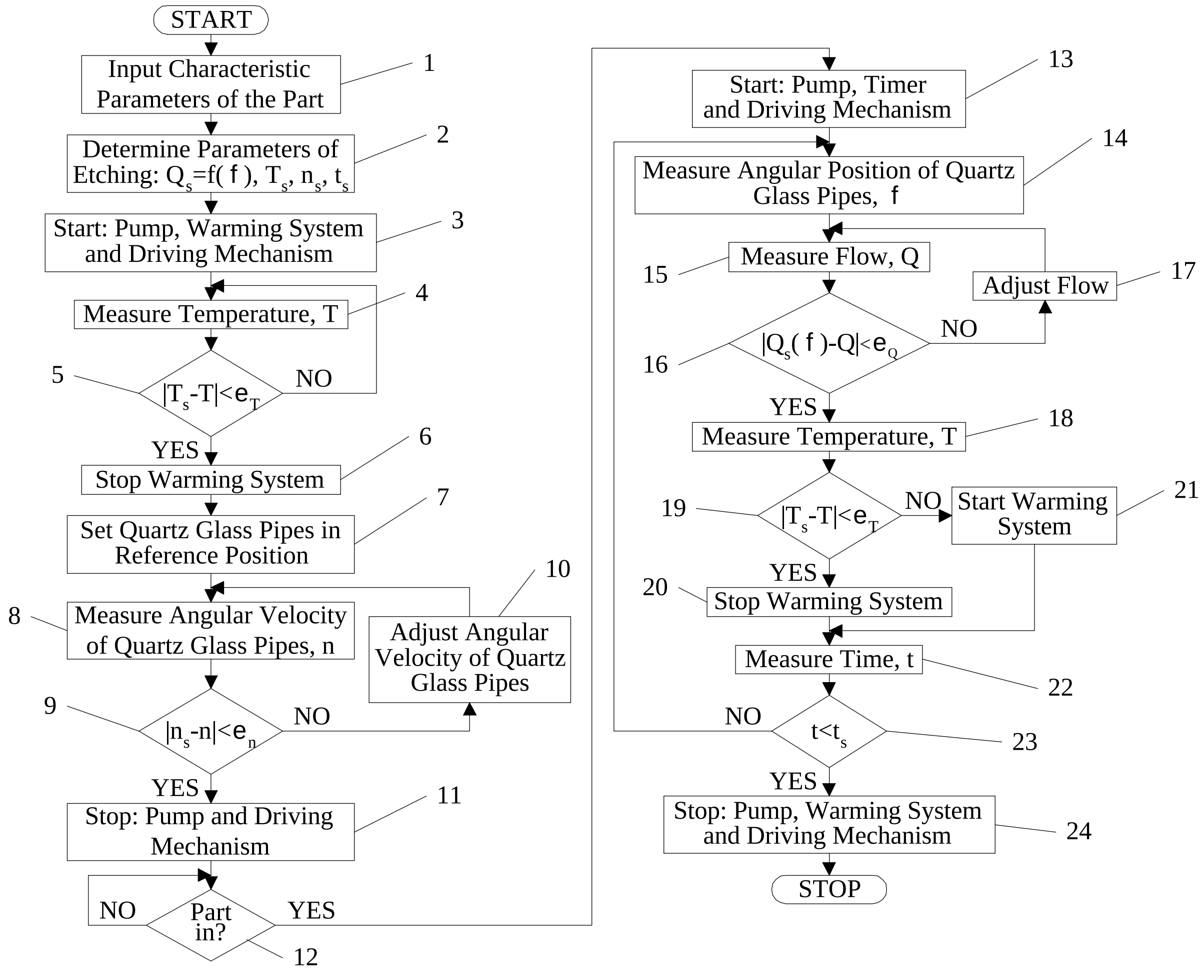


Fig. 2 The logical diagram of the application program

The item 2 shows the determination of etching process parameters: flow $Q_s=f(\varphi)$ and temperature T_s of etching solution, angular velocity of the quartz glass pipes n_s, time of etching t_s, when is known apriori an etching data base. For a differential chemical attack, the flow Q_s is according to φ rotation angle of the quartz glass pipes.

The item 3 shows the start of the pump, the warming thermostatic system and the d.c. motor.

The item 4 shows the measuring of current temperature T of the etching solution, which is in the vat. The item 5 shows comparison between the measured temperature T and the temperature T_s determined in the frame of item 2. If the measured temperature is not between $T_s \pm \varepsilon_T$, where ε_T is the temperature error, a delay cycle starts. The item 6 shows the stop of the warming thermostatic system.

The item 7 shows the rotation of the quartz glass pipes in reference position that permits to determine the φ angle, in case of use a relative encoder.

The item 8 shows the measuring of current angular velocity n, of the quartz glass pipes.

The item 9 shows comparison between the measured angular velocity n and the angular velocity n_s established in the frame of item 2. If the measured angular velocity is not between $n_s \pm \varepsilon_n$, where ε_n is the angular velocity error, the program goes to item 10, which shows the adjustment of angular velocity. The item 11 shows the stop of the pump and the d.c. motor.

The item 12 shows a questioning of user about the presence of the part in the etching installation. If the answer is negative, a delay cycle starts. The item 13 shows the start of the pump, the timer and the d.c. motor.

The item 14 shows the measuring of current φ angle, of the quartz glass pipes.

The item 15 shows the measuring of current flow Q, of the etching solution, according to φ angle.

The item 16 shows comparison between the measured flow Q and the flow $Q_s(\varphi)$ determined in the frame of item 2. If the measured flow is not between $Q_s(\varphi) \pm \varepsilon_Q$, where ε_Q is the flow error, the program goes to item 17, which shows the adjustment of flow. The item 18 shows the measuring of current temperature, T.

The item 19 shows comparison between the measured temperature T and temperature T_s determined in the frame of item 2. If the measured temperature is not between $T_s \pm \varepsilon_T$, then goes to the item 21 which shows the start of the warming thermostatic system. The item 20 shows the stop of the warming thermostatic system.

The item 22 shows the measuring of current etching time, t.

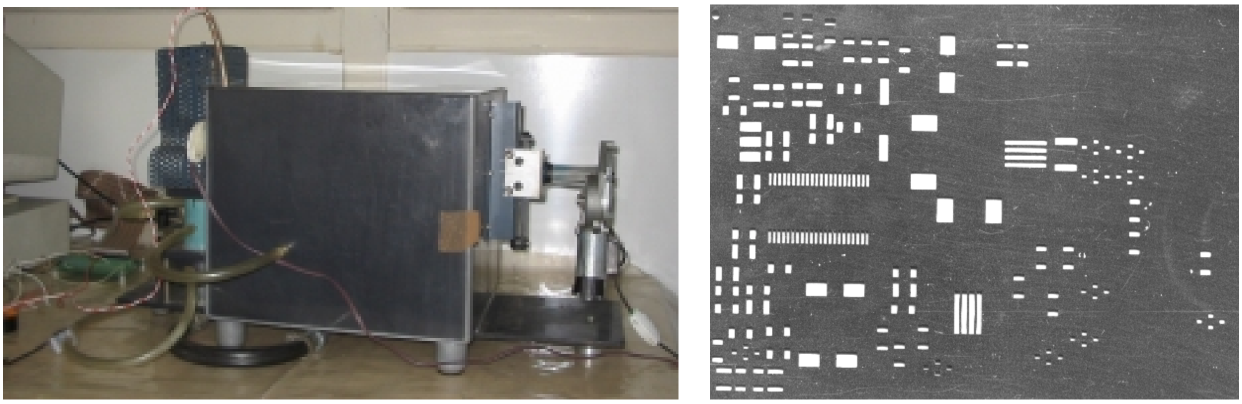
The item 23 shows comparison between the measured time t and time t_s determined in the frame of item 2. If the measured time is less than time t_s, the program goes to the item 14 else executes the item 24, which shows the stop of the pump, the warming thermostatic system and the d.c. motor.

Technical parameters of the etching installation are: vat capacity: 10 l, overall size dimensions: 310 x 545 x 417 mm^3, flow: 0÷0.5 l/s; etching solution temperature: 20÷60°C, pump drive motor rotation speed: 2800 rot/min, pump motor supply voltage: 220V a.c., drive motor rotation speed of the pipes with nozzles: 0÷40 rot/min.

EXPERIMENTAL

In our experiments we have obtained very fine metallic masks, created by *differential chemical attack*, with different rate of etching, according to the dimension and disposition of the holes on surface of the part. The minimum dimension of the hole/width of lines and apertures represents around 1.5 of processed material thickness. The obtained resolution and precision are around ± 0.05% of dimension.

Figure 3a) presents a photo of the achieved laboratory installation. Figure 3b) shows an image of a test part. The selective protection of the part surfaces was performed using laminated photoresist, exposed 1.5 min. to UV-rays via two positive centered photo-clichés in a vacuum plant and developed in potassium carbonate solution. The corrosion was performed in ferric chloride solution 28%, with a flow of 0.3 l/s and a temperature of 30°C. The “sweep” speed was equal to 8 rot./min and the attack time was 2.5 min. The minimum etched dimensions were 0.5 mm (gap) and 0.2 mm (line), according to the imposed functional conditions.



a) b)

Fig. 3 The laboratory installation, controlled by PC via a data acquisition board (a). Test part processed from argentan of 0.2 mm thickness, using bilateral attack through two centred photoresist masks (b)

CONCLUSIONS

The processing method by selective chemical attack, using photolithography as a protection method, allows obtaining the complex configuration, without fins or mechanical stresses, into large types of material like stainless steel, copper, brass, nickel-silver, beryllium-copper. We have experimented these materials in frame of testing of the optimized model of automatic etching installation. The corroding was performed in ferric chloride solution.

The installation proposed uses the spraying method, which accomplishes optimal performance: strong impact with the surface of the part conditions, refreshing of the solution, high oxidation power of the solution, the effect being a high etching factor (ratio of processing depth to lateral etching) and a short attack time.

The etching rate can be modified depending on the flow of the solution jets through the spraying nozzles, the temperature and the concentration of the solution. For a differential chemical attack, the flow varies with the sweeping angle of the quartz glass pipes.

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