PLASMA-REMOVING OF POLYMERIC LAYERS FROM INTEGRATED CIRCUITS*

OTO ŠTIRAND**, JIŘÍ SKÁLA**, JARMILA KODYMOVÁ**, BOŽENA KRÁLIKOVÁ**,
Praha

To meet the demands of technical electronics we have performed experiments in the plasma-removing of polymeric layers from integrated circuits. It is necessary to remove the polymeric layer without perturbing the electronic circuits. We have used high frequency low pressure discharge in oxygen and measured the speed of decrease of the layer in materials of various products. The efficiency of layer removing is for various materials essentially different.

УСТРАНЕНИЕ ПОЛИМЕРНЫХ ПЛЁНОК С ИНТЕГРАЛЬНЫХ СХЕМ С ПОМОЩЬЮ ПЛАЗМЫ

Учитывая требования технической электроники были проведены эксперименты по устранению полемерных плёнок с интегральных схем. Эти полимерные плёнки необходимо устранить без повреждения схемы. Для этого использовался высокочастотный разряд в кислороде при низком давлении и измерялись скорости утончения плёнок для материалов различных изделий. Эффективность устранения плёнок для отдельных материалов существенно различна.

I. INTRODUCTION

Microelectronic circuits are usually suffused with epoxy resins which protect the circuit elements from both a mechanical damage and corrosive action of the surrounding atmosphere. The fact that such a device cannot be taken to pieces makes the analysis of defects in the circuit difficult. It has therefore become necessary to remove for purposes of practical application their connections. The use of a mechanical way for removing the enclosure proved to be the least suitable. Chemical treatment, which has been employed most frequently so far can, however, also damage the components. By reason of this, the specific interaction of ionized gas with the solid state, where mainly the non-isothermal state of the partly

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** Fyzikální ústav ČSAV, Na Slovance 2, CS-180 40 PRAHA.

ionized gas (plasma) plays an important role, has lately been utilized [1]. The higher energy of some created charged particles in such gas is transferred to the gas molecules. The additional neutral and charged particles in both the basic and the

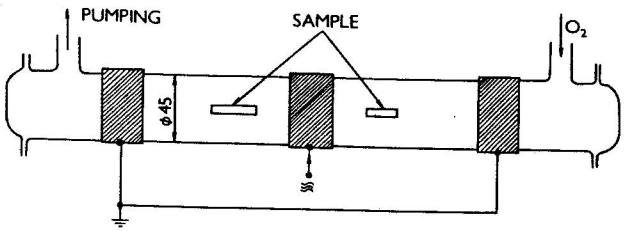

Fig. 1. Non-cooled discharge tube.

excited states are produced by elementary processes like ionization, dissociation or excitation. These particles are able to create or break the chemical bonds in the solid at a lower temperature. The low temperature is just the very thing which is needed when removing the enclosure. The damage of the electronic circuits is thus excluded. The oxygen plasma used in this process does not destroy either the masking thin SiO_2 films or the aluminium connections of the circuits, which is another advantage of this method.

II. EXPERIMENTAL ARRANGEMENT

The high-frequency discharge in oxygen was excited by a hf generator with capacitive coupling between the external ring electrodes of the quartz tube. The adapted generator worked with the frequency of 4 MHz and the maximum power 200 W. The samples were put into the discharge tube by a special holder (Fig. 1). A flowing system with a rotary pump was employed. Technical oxygen was introduced into the discharge space through the needle valve. The gas flow was about 2.5 cm^3s^{-1} and the pressure was kept at 0.6 torr (80 Pa). The high-frequency power and consequently the plasma density were set at such a value that the sample temperature did not exceed 190 °C. This temperature was chosen with regard to the expected resistance of the integrated circuit. The sample temperature was determined from the voltage (drop) at one of the P-N junctions of the circuit in the previous direction at a constant current. The temperature dependence of the voltage was calibrated beforehand. The temperature was measured during a short switching off of the hf field.

To achieve a higher plasma density and maintaining at the same time the same sample temperature, we used a water jacketed tube (Fig. 2). The sample was placed directly on the wall of the discharge tube and in this way cooled.

The products of the polymer decomposition were removed mechanically after the sample had been taken out of the tube. The loss in weight of the sample was determined by microweighing.

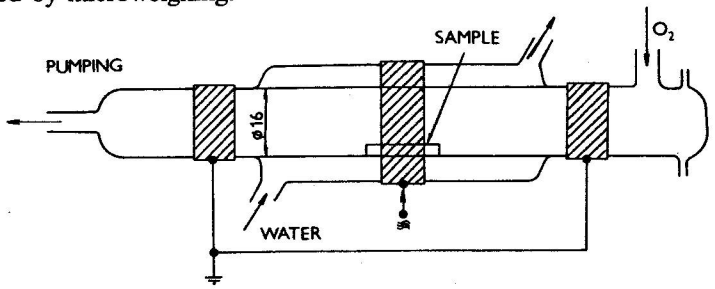

Fig. 2. Water-jacketed discharge tube.

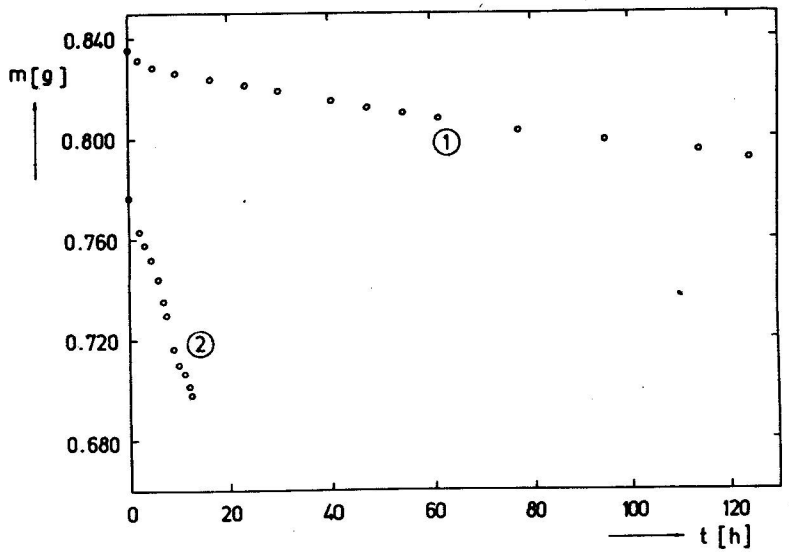

Fig. 3. Dependence of sample weight on etching time: 1) in noncooled discharge tube, 2) in cooled discharge tube (sample POLYSET material without top layer).

III. RESULTS

The experiments were made with samples with both domestic (Tesla Rožnov — type of epoxy resin) and foreign production (VEL 5). In some samples the top layer of the epoxy cover was mechanically removed to shorten the etching time.

In Fig. 3 there are plotted the rates of the polymer losses when using a non-cooled tube with a lower density of the active plasma particles (curve 1) and

a cooled tube with a higher density of the active plasma particles (curve 2). In the figure it can be seen that the rate of the polymer loss in the cooled discharge tube increased nearly twenty times. The samples used here were these with the mechanically removed top layer.

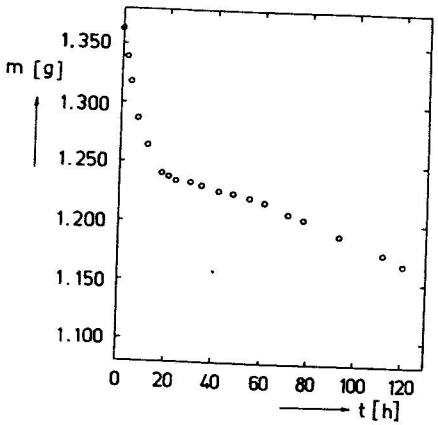

Fig. 4. Dependence of the sample weight on etching time. Note the two different rates of epoxy removal (non-formed sample — material VEL 5).

Fig. 4 shows the rates of the polymer loss in a non-cooled tube and the sample in the original state. Two rates of the epoxy removal can be seen. This may be caused by the inhomogeneity in the epoxy cover near the surface, e.g. the lower content of the filler in the top layer.

The effect of the polymer removing is probably caused by breaking the chemical bonds, which creates fragments of lower molecular weight. Volatile substances are carried off by the lowing gas. On the sample surface there remained only the rest of the filler, which was removed mechanically. On the basis of observation the sample surface with the microscope it seems that on the etched surface the epoxy resin itself, has been removed completely and the remaining powder is only the filler.

The used method minimizes the danger of the damage of electronic circuits. In addition to this method there can be used a simple masking technique, e.g. using silicon grease, which is not affected by oxygen plasma.

So far, three to seven days of etching have been necessary for removing the epoxy resin [1]. This time is in agreement with our results obtained in the non-cooled tube (Fig. 3).

Our experiment shows that it is possible to shorten the required time by cooling the sample and the discharge tube.

REFERENCES

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