Optical Control of Laser Cut Stencils

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Abstract – **The report explores the preparation of stencils for the needs of the surface mounting, and the application of optical control with their qualification. Cases of control after the technological preparation and after additional finish processing are considered. Possibilities are discussed for examination of the surface of the stencil and the vertical edge after cutting. For some cases, destructive control methods are used. Experimentally achieved results are presented**

Keywords – **optical control, laser cutting, stencil, SMD.**

I. Introduction

In surface mounting, the printing application through a metal mask could be adopted as a classic method for application of solder paste [1]. There are two main technologies for preparation of such masks: through chemical etching [2] and through laser cutting [3]. With chemically etched stencils, different profiles of the apertures can be obtained depending of the mode used, as well as stencils for application of paste with various thickness. With the laser cut stencils, a more vertical edge is obtained, and there is practically no change in the designed size of the aperture. In fig. 1, vertical profiles of a chemically etched and a laser cut stencil are shown.

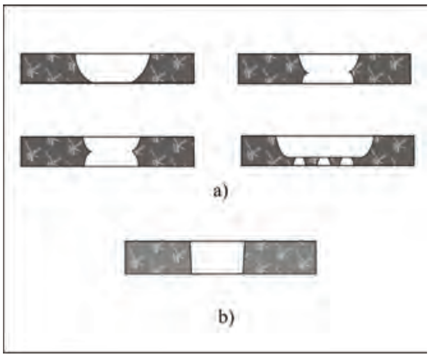

Fig .1. Profiles of stencils prepared through etching a) and cutting b).

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A definite difficulty with both methods of preparation is the obtaining of extra small apertures for application of fine-step imprints. In these cases, a technology for electrochemical growing of stencils can be used [4].

II. Optical Control

The optical control is the main and the most widespread method with the surface mounting. It is widely applied at all stages of the production cycle. The optical control itself can be applied with visual assessment of the process by an operator (manual optical control), or through usage of technical vision systems, the so-called automatic optical control [5]. The standard optical control is used as non-destructive control of the processes: application of solder paste, position of elements, quality of the solder joints. On fig. 2, result of optical monitoring of a defect with soldered components is shown.

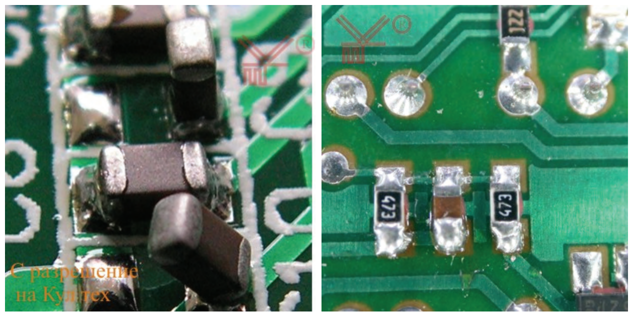

Fig .2. Optical control of soldered components.

The optical systems can also be applied with automated position of elements [6] (for identification of the coordinates) – fig. 3, as well as with size measurements.

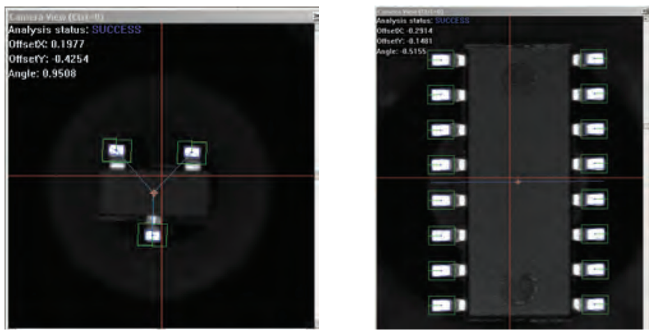

Fig .3. Defining coordinates through a technical vision system.

The optical control can also be used as a destructive control.

Its most typical application is for qualification of the solder joints and examination of the intermetallic phases.

III. Stensils Preparation

There are two main processes for preparation of stencils. The photolithographic method uses one-sided or two-sided application of photoresist (lamination of dry photoresist), exposing and development for formation of the topology of the stencil and subsequent chemical etching. During this process, special attention should be paid to the following elements:

- Precise coordination of the photo patterns for two-sided etching
- Evenness of the etching process throughout the whole area
- Recognizing the change of size as a result of the underetching.

The first element of coordination can be controlled optically still in the process of preparation of masks. The second element is harder to control during the process itself. The third element is usually defined experimentally, and presents a technological tolerance. For the quality preparation of stencils, optical control is needed at each of the stages.

On fig. 4 a result of optical control of the evenness of etching of a stencil through the photoresistent mask is shown. Shown is uneven etching , etched apertures with non-removed photoresist.

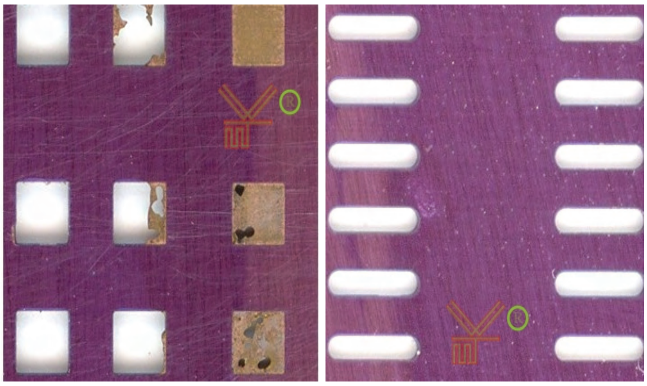

Fig .4. Optical control of the etching during the preparation of a stencil.

When monitoring with high zooming, the underetching, the evenness of etching along the aperture, and, in some cases, the dislocation of the patterns can be defined. Such control is carried out through monitoring by microscope and the respective size measurements. On fig. 5, a fragment of a chemically etched aperture with underetched section and visible displacement of the mask for both sides is shown. The underetched contour 1 is seen through the photoresist, and the displacement 2 is outside the contour of the photoresist.

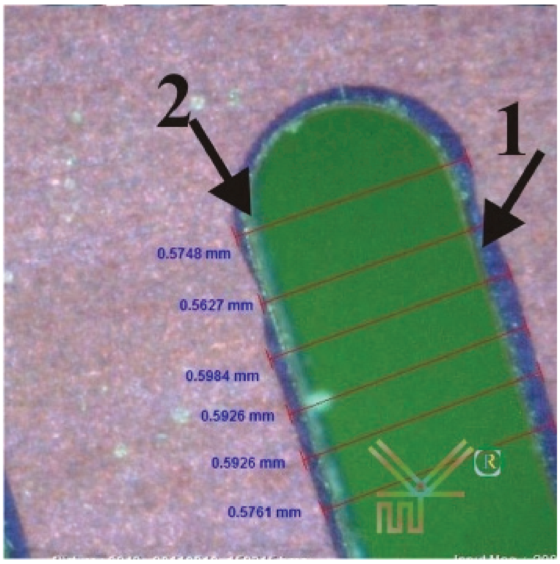

Fig. 5.Underetching of a stencil.

In spite of the relatively easy finding of size changes and lack of coordination, the optical monitoring of the surface cannot provide complete information for the process of etching. For this purpose, destructive control is applied through preparation of thin sections. On fig. 6, examples of the vertical profile of stencils obtained through etching are shown.

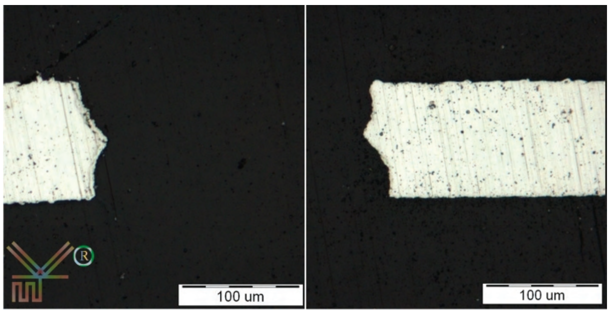

Fig. 6. Left and right profile of an etched aperture.

Depending on the mode of etching and the solutions used, both the profile and the surface can change. These results are shown on fig.7.

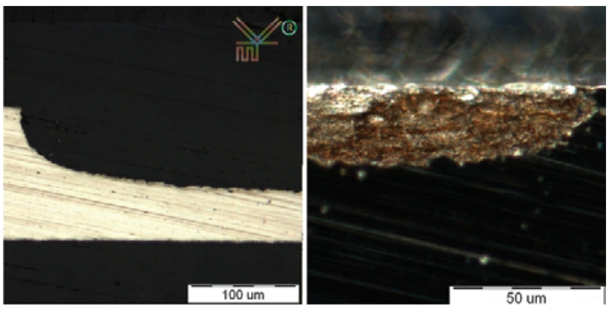

Fig. 7. Profile and surface with one-sided etching of a stencil.

In laser cut stencils the three elements which should be controlled for the chemically etched stencils are practically missing. With them, through the laser beam the aperture is cut immediately by the contour, and thus there is no need to coordinate patterns, the cutting is all the same throughout the whole area and there is no underetching. The optical control of the surface can provide an answer for the size of the aperture. With high zooming the spatters of molten metal can also be found. Such are shown on fig.8.

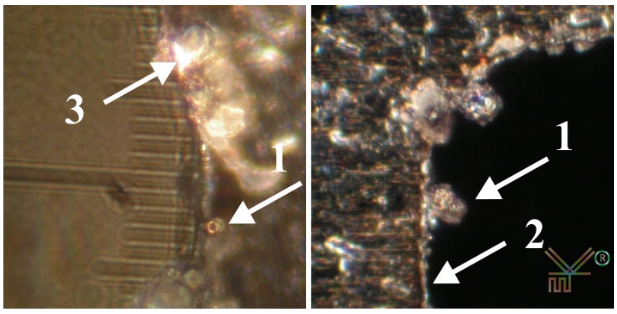

Fig. 8. Spatters of metal in laser cut stencils. 1 – spatters of metal, 2 cut contour, 3 big spatter.

The removal of these defects requires additional processing of the surface. It is carried out mechanically, and then again optical control of the surface follows. On fig. 9, depiction of processed and non-processes part is shown.

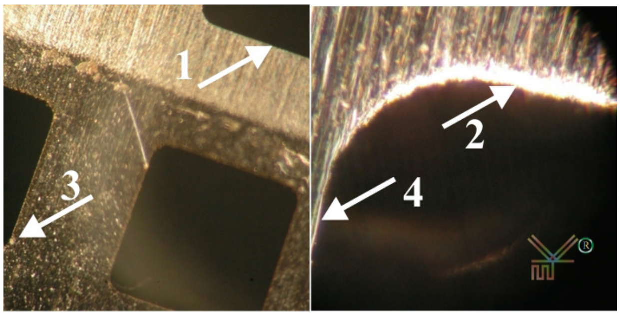

Fig. 9 Surface of a laser cut stencil after mechanical processing: 1 - processed edge front side, 2 – processed edge back side, 3 – spatter of metal, 4 – edge in the direction of the processing.

In this case the surface monitoring also cannot provide a full picture of the process. The presence of glare (2 on fig. 9) shows that in vertical direction changes are also monitored. On fig. 10a and 10b, vertical profiles of laser cut stencils are shown before and after mechanical processing. It is seen that as a result of the processing, rounding of the edge is obtained, a result both of the position of the edge towards the direction of processing and the pressure from the system.

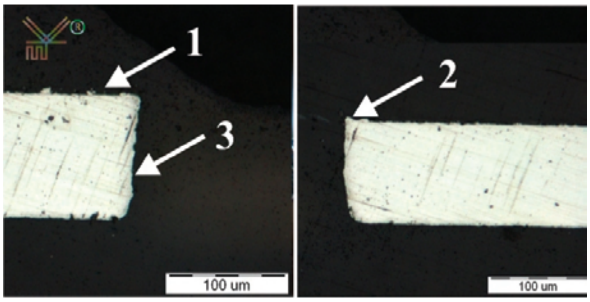

Fig. 10.a. Non-processed stencil.

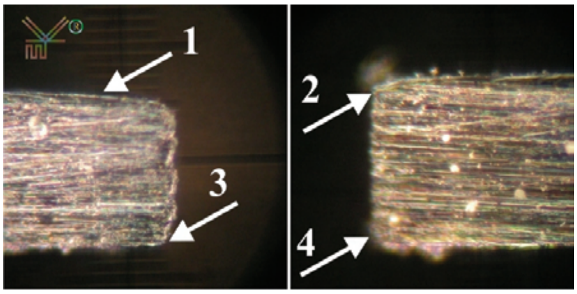

Fig. 10.b. Mechanically processed stencil.

The monitoring of the edge with high zooming enables monitoring both of the traces of the laser beam and internal remainders of the melt – fig. 11.

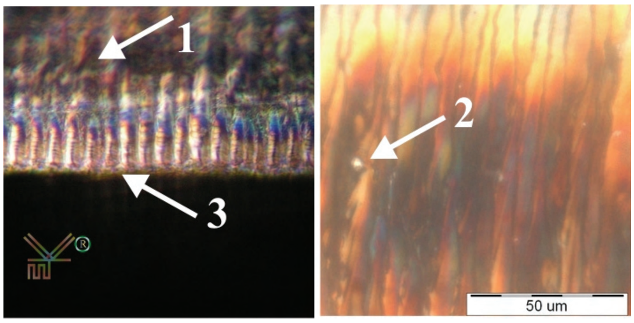

Fig. 11. Profile of laser cut stencil.

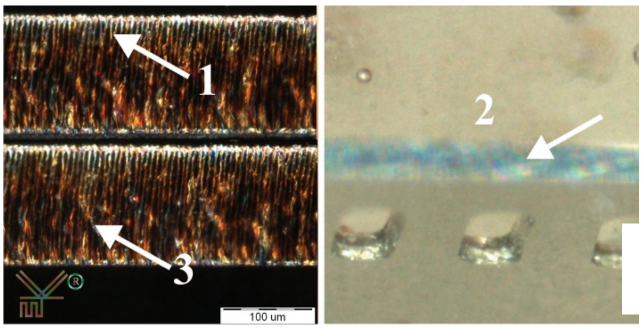

Fig. 12. Profiles of stencils with various optical monitoring.

On fig. 12, comparison of different areas of a laser cut stencil is shown. While on the surface there is regularity of the profile, in depth the surface has statistically random profile.

III. Conclusion

The experimental results carried out by monitoring and qualification of stencils showed that their complete characterization requires monitoring both of the surface and the vertical profile of the stencil. With the surface monitoring, assessments can be given for sizes, evenness, repeating of the apertures made, but we have no information for the profile. Such an assessment can be made through destructive control and making cuts on the stencils. These cuts can be monitored immediately or through cross-sections. The experimental results are obtained through studying stencils produced by different companies in Bulgaria. The laser cut stencils are made in IVAS TEH OOD , with G 6060 machine, and the micro-sections are examined in FESTO Production EOOD, within the PhD studies of the authors.

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