Destructive Testing Design for Surface Mounting

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ABSTRACT: *This paper reviews cutting methods to perform destructive testing for surface mounting. Demonstrates two ways of controlling processes during the production of technology equipment and process control. Demonstrates experimental results from a process for the production of laser-cut stencils.*

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1. Introduction

Surface-mount technology is a major technology used in the manufacture of electronic equipment, from basic LED light sources [1] to complex computer systems and mobile devices [2]. Control over the technological process is crucial due to the widespread use of this technology. Destructive and non-destructive control methods exist. Optical methods for control are applied more frequently, including automated process control methods [3]. In spite of this automation, there are control points where the automated optical control systems are inappropriate to use. Those are processes that are applied relatively rarely and are designed to control individual elements. For example, control over application of solder paste in stencils. Solder paste-laying masks are manufactured based on different technologies [4], and the optical control is applied to assess the manufacturing technology. Both the dimensions and the shape of the resulting holes can be controlled though this method [5 by us]. The standard optical control in stencils sometimes is not able to evaluate the impact of all technological parameters and cannot address all questions. This paper will demonstrate a method for optical control on stencils that allows for a broader assessment of the process for laser cutting of stencils.

2. Laser Cut Stencils

Laser cut stencils feature many advantages compared to chemically pickled ones. Foremost, one can produce large, in terms of area, masks where the same precision in making the holes on the entire area is applied. At the same time, there are no limitations related to chemical methods' pickling to produce small holes.

An advantage of the method is also that a lower quantity of consumables is used during the manufacture of the stencils. Laser cutting treats the metal plate directly, as opposed to chemical etching, where the metal plate undergoes a procedure of preliminary treatment through photolithography, in addition to expenditures incurred to pickle and rinse the metal plate.

An advantage of the laser cut stencils is the ability to get relatively vertical walls of the holes – Figure 1.

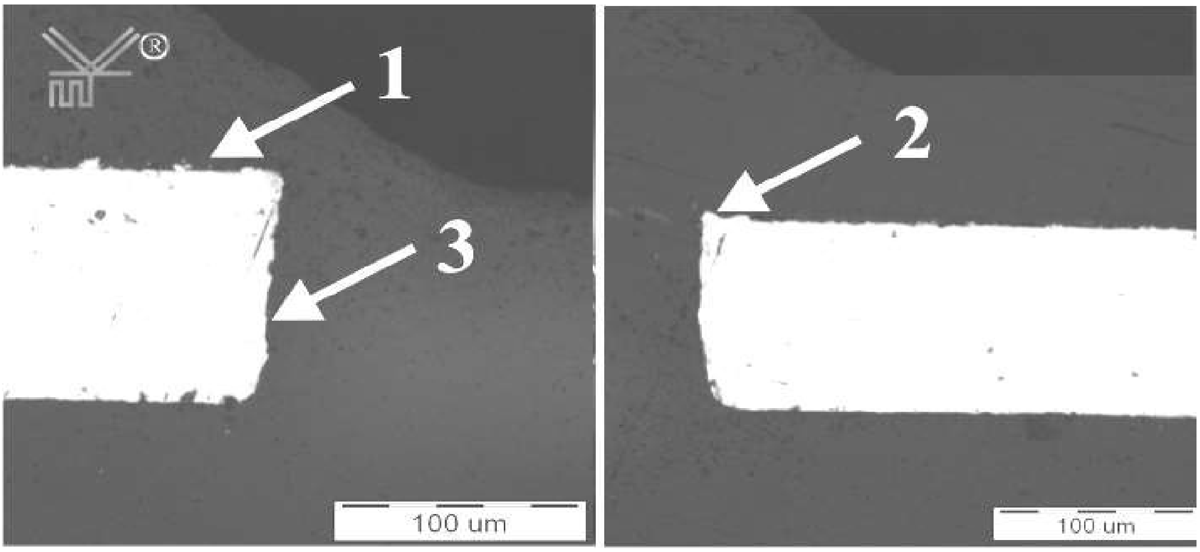

Figure 1. Cutting of a laser cut stencil. 1- plane of the mask, 2 – edge of the hole, 3 – wall of the hole

This verticality of the cutting, combined with the extreme movement precision of the laser beam and the small dimensions of the spot (cut), allow for complex holes featuring different orientations – figure 2.

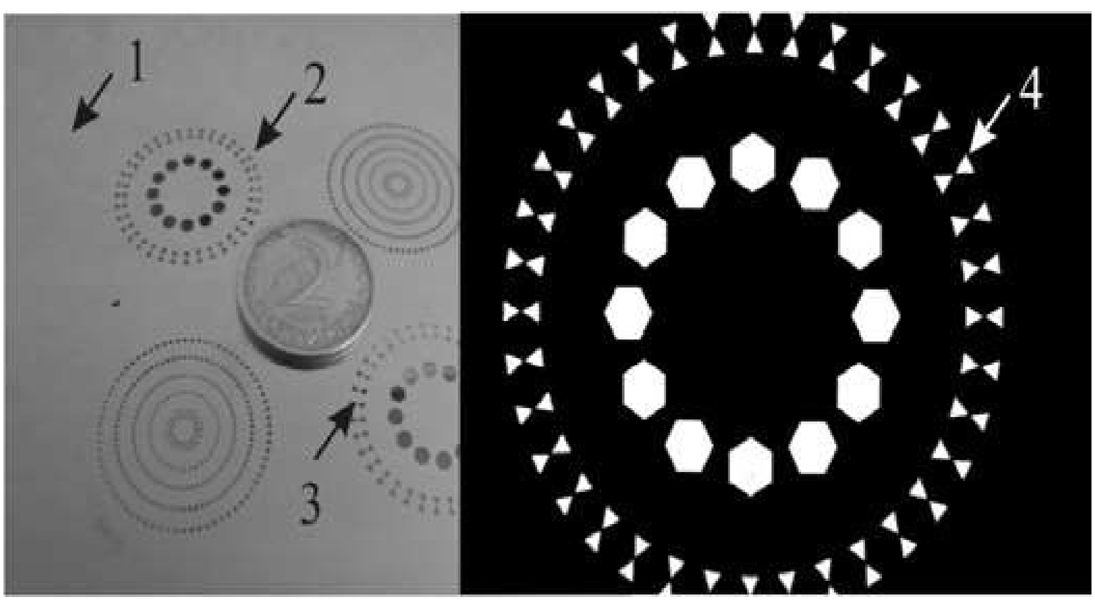

Figure 2. Shapes of holes in laser cut stencils

3. Optical Control

Both destructible and non-destructible optical control can be applied in the case of laser cut stencils. The shape and the dimensions of the holes can be viewed in horizontal plane in the case of non-destructible control. Variants of such an observation in two modes are showed on Fig. 2. In the case of observation in reflected light mode, one can see the surface of a stencil -1, the shape and location of different holes – 2, 3. For the purpose of precise control over the shape and dimensions of the holes, an observation method based on transmitted light is used and then figurations become contrasting – 4.

In the case of these stencils, the quality of the wall itself is crucial, not only the preciseness of the hole and the verticality of the walls. It might feature a different surface as well as defects – Figure 3.

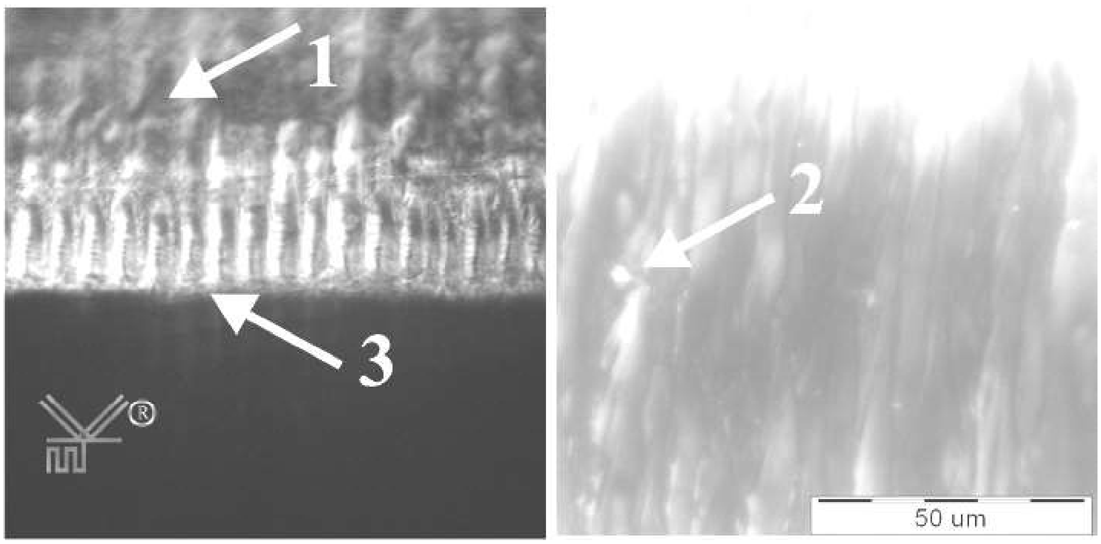

Figure 3. A wall of cut stencil. 1 – wall, 2 – defect, metal droplet, 3 – edge

Samples that have been cut along the holes have been used, allowing for better observation, while enabling observation of edges and walls – Figure 4.

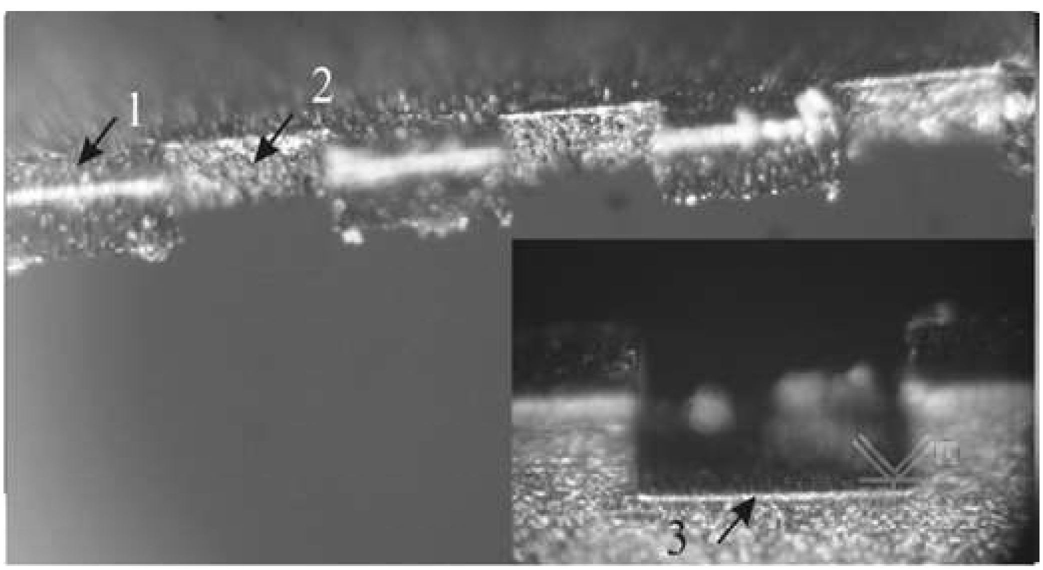

Figure 4. Samples for observation of cuts

At the above figure, one can see the surface of the stencil - 1, its wall – 2, and the edge of the hole – 3, where angled lighting is used.

In optimizing the modes of operation of the laser (power, impulse frequency, duration, movement speed), the possibility to compare the outcome of cutting against the consequential surface of the wall is essential. It can take the shape of channels, grooves, lusterless, and others – Fig. 5.

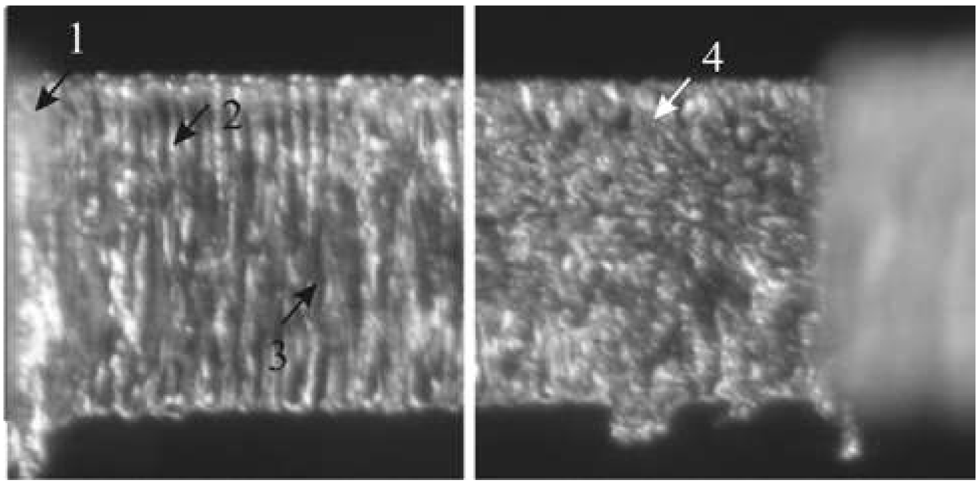

Figure 5. Different surface in laser cutting

Figure 5 shows the shapes of the wall at edge (angle of the hole) – 1, top of a groove – 2, pore – 3, lusterless surface – 4. The direct optical observation does not allow to assess the surface of the cut in detail despite that special samples have been made.

The height of the grooves, the presence of sub-surface cavities, etc., should be assessed. The assessment of the surface as a profile of the plane in different levels is of special interest.

4. Experimental Results

A standard approach to profile a surface involves the use of mechanical profile-measuring devices. Here, there are two restric-

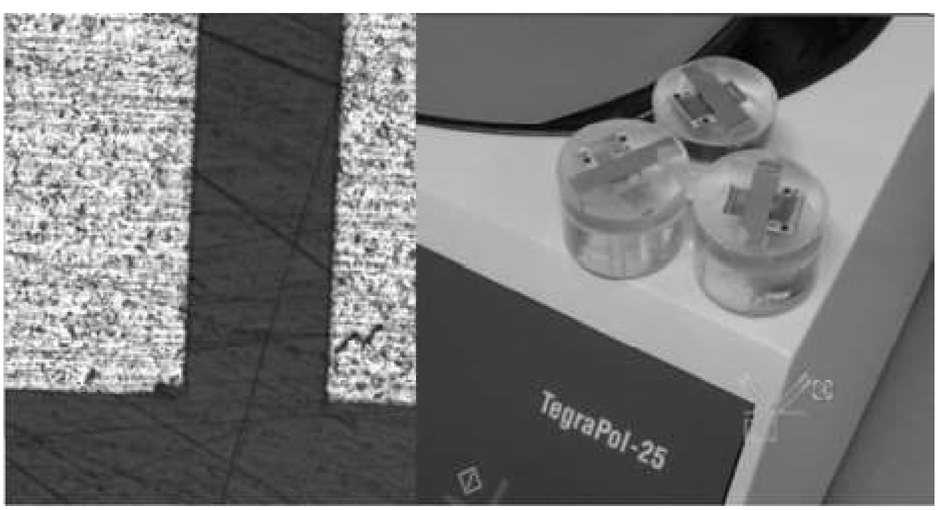

Figure 6. Samples of cutting in horizontal plane

tions. The wall of the hole is relatively small and narrow, requiring high level of precision during manipulation. On the other hand, the mechanical profile-measuring device is not applicable in the case of complex shapes – for example, curved groove. Bearing the abovementioned in mind, a decision has been made to make horizontal cross-sections, taking profiles of the hole. For this purpose, epoxy resin has been poured on samples of stencils, which have been placed vertically to the cutting plane – Figure 6.

The width of the sample has been under continuous control during the cutting process to determine the cutting plane. The cutting has been performed at 250 rpm, pressure of 30 Newtons per sample, and processing period of 30 seconds. Cut levels have been within 30 µm. In the beginning, cuts appeared at the levels of the metal droplets that occurred due to the cut – Figure 7, and then at the surface of the stencil.

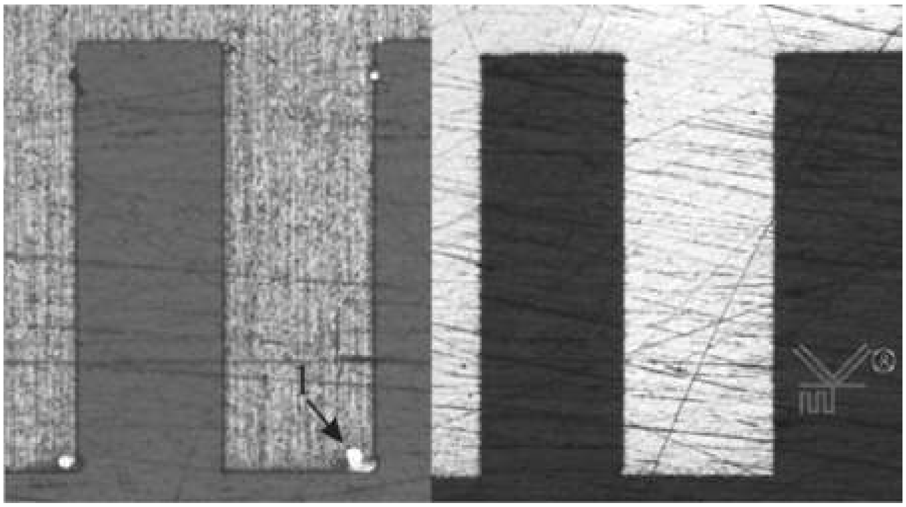

Figure 7. Horizontal cutting of a stencil. 1 – metal droplets

When performing cutting at particular distances, the shapes of the wall as resulting from different handling techniques emerged – Figure 8.

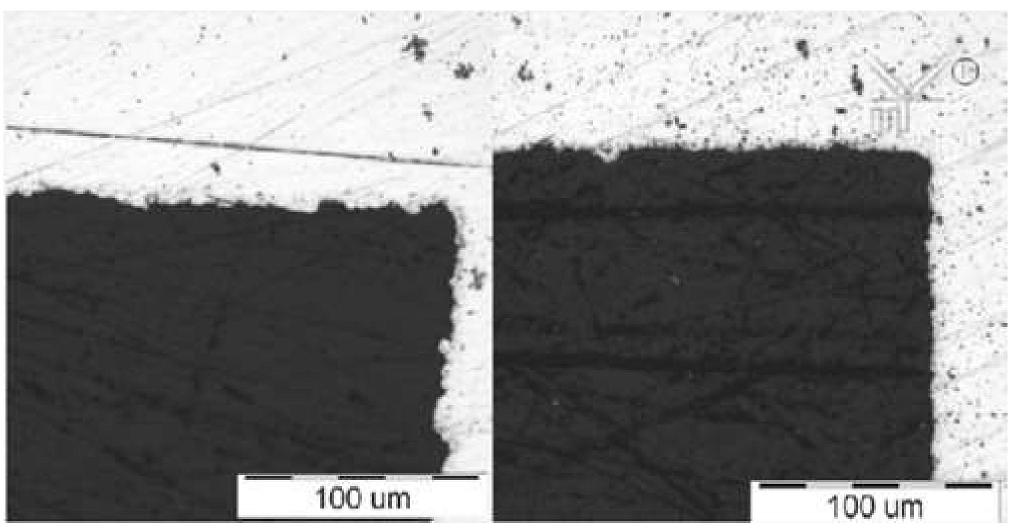

Figure 8. Different modes of cutting. Cuts after grinding

Software has been used to process the optical image to increase contrast and get sharp contour – Figure 9.

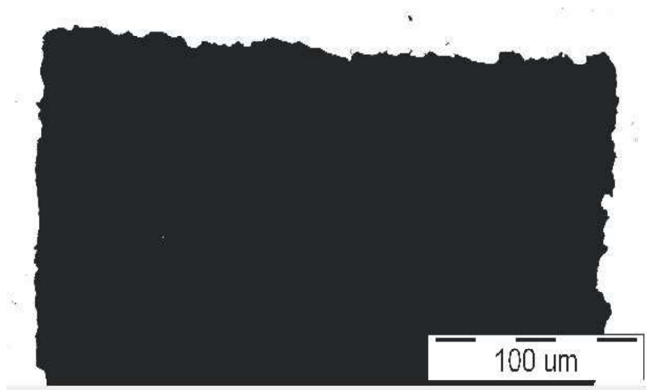

Figure 9. Contrast processing of a cutting

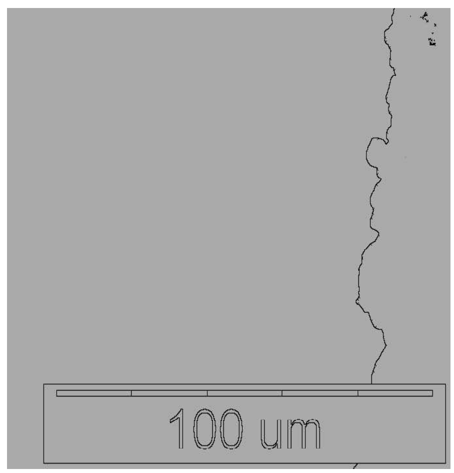

Figure 10. Contours of the cut surface after extracting

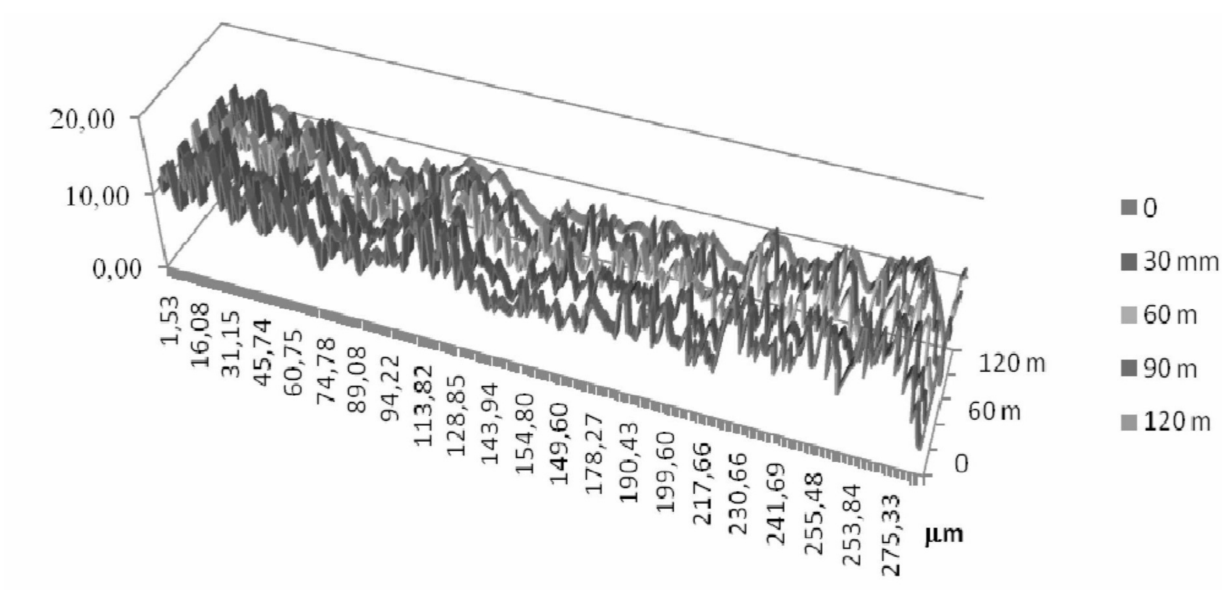

Figure 11. 3D diagram

A diagram of the contour itself is easy to extract, following the application of a respective processing method, where such a contour exists – Figure 10.

The transformation of the resultant contour into digital data is not hard to realize as well. All and every cut is processed using the demonstrated methodology and is transformed into digital data. Those may be presented graphically and may be used in different types of processing. The below figure 11 shows a sample how the results derived from the wall's contours can be displayed as a 3-D diagram.

5. Conclusion

This paper provides a method for destructive control over laser cut stencils designed for surface-mount assembly. This method allows for a wall profile of the hole, measured in absolute measurements, to be achieved and makes it possible to complement the assessment of cutting parameters. Combining profiles that have been accomplished at different cut levels with digital presentation of those profiles allows for creation of a 3-D digital image of the surface.

The efforts to obtain such a digital image using other methods, like mechanical scanning through profile-measuring device, face difficulties.

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