Reduction of burring effect on LTCC laser cutting

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***Abstract*—When LTCC tapes are laser cut in the green state an edge burring effect can appear, especially for narrow structures, what can make the samples unusable for some applications. To reduce that defect, the samples can be pressed in a uniaxial press. This paper investigates which pressing condition is the best to reduce the burring. It presents how the samples were fabricated and the pressing conditions tested. After the pressing process, it was possible to reduce the burring height by 97%.**

***Keywords*—LTCC; MEMS, burring effect; laser cutting.**

I. Introduction

LTCC (Low Temperature Co-fired Ceramic) is a sub-group of the technique called MCIC (multi-chip integrated circuit). This technology started around 80's and became more popular in the last decade. The LTCC tape composition includes organic components, glass and alumina. During the sintering process, the organic components burn out and the glass particle melt, joining the ceramic particles, providing a high performance subtrate. LTCC is a good substitute for PCB and its applications are cover RF microwave circuits and sensors. One advantage of using LTCC is the fabrication of electronic devices with low cost and high performance which provides a huge progress in microelectronic systems [1][2].

LTCC can also be used to produce fine ceramic parts, cavities and microchannels. To process the LTCC, an important step is the laser cutting. This process provides the flexibility to fabricate structures with almost no restrictions on the shape and dimensions. Despite the laser cutting is a great processing tool, thermal defects like glass bids, local sintering and plastic deformation can occur due to the interaction with the laser. A common defect of the cutting is the creation of a burr on the edge of the structures. This problem is caused by a combination of heating and softening of the areas surrounding the cut and the pressure of the vapors produced by the sublimation of the LTCC that are expanding to escape out of the cutting trench. This effect is also observed in plasma cutting of materials [3][4][5].

The objective of this paper we present the investigation of how to overcome the burring created with the laser cutting of narrow structures in LTCC. To reduce the edge burr, six pressing conditions were evaluated, changing the applied pressure and time.

II. Experiment

The selected shape to study the burr formed by the cutting process was a beam-suspended frame structure called isostatic holder, part of packaging for an atomic clock developed at CSEM. This shape was chosen because it has narrow structure that need to be cut from a thick (532um) tape. Samples were prepared according to the process described by the following steps:

- Four Heralock HL2000 LTCC tapes from Heraeus were laminated on a KEKO Isostatic press model ILS-66 at 70 °C and 9 MPa for 10 minutes, then they were conditioned in the Chamber Ethik Technology model 400 – 4ND at 100 °C for 30 minutes. Finally, the fiducials were punched using a KEKO Punching Machine model PAM – 8SCC.

- After, the isostatic holders were cut on Nd/Yag laser from Aurel, model ALS 300L using the following parameters: electrical current = 17,5 A, speed = 1,0 mm/s, frequency = 200 Hz and power = 24,9 W.

After the laser cutting, sixteen samples of the isostatic holders were selected. The image in Figure 1 is an example of one of the holders.

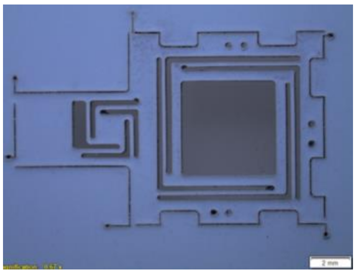

Fig. 1. Isostatic Holder before the pressing process.

These samples were measured on Optical Profilometer Cyber Technologies model CT 100. To measure the burr height, the base reference (green) was set on the center of the beams and the measure reference (red) was placed on the edge of the beams, using the function "Height Avg". This function returns the average height of the area selected in red. In Figure 2 is shows an example of the measuring process. Each peak refers to a part of the structure captured by the sensor. It is a zoom of the image at the bottom right of the figure

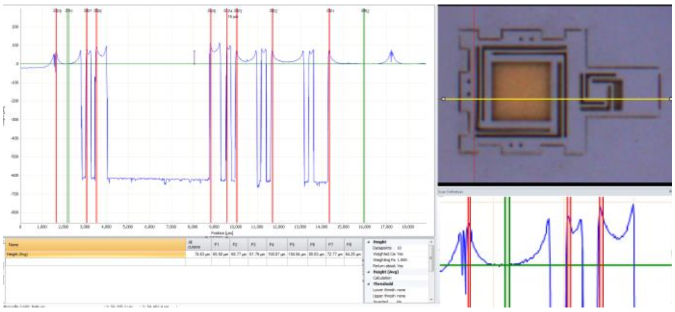

Fig. 2. Measurement process of the bridges burring.

The result of the measurement is the height difference between the center and the edge of the bridge. Besides the burr height, the bridges width were also measured using the profile data, before and after the process to quantify the deformation of the structures.

After the measuring process, the samples were pressed on Stacker KEKO model SW – 6VL using the following conditions at 40 °C:

Table I. Pressing conditions tested

Condition	Pressure (bar)	Pressing Time (seconds)
C1	1	5
C2	1	10
C3	1	30
C4	1	60
C5	2	5
C6	2	10
C7	2	30
C8	2	60

After the pressing process, the samples were measured again to evaluate which conditions decreased more the burring, and at the same time did not cause a huge deformation on the structures.

Finally, all samples were sintered on Elevator Furnace Schimid model 8K24 – 24 - 4 using the following profile: 3 °C/minute to 100 °C, 2 °C/minute to 450 °C, 10 °C/minute to 865 °C and stayed in this temperature for 30 minutes. The cooling rate used is 10 °C/minute. After the sintering process, the preselected samples were measured again to see if the shape was modified in the process. All measurements were made in the same positions as previous ones.

III. Results

The plots in Figure 3 represent the data of the burr height before and after the pressing process and the percentage of variation of this values (% Δ burring height) for the eight tested conditions.

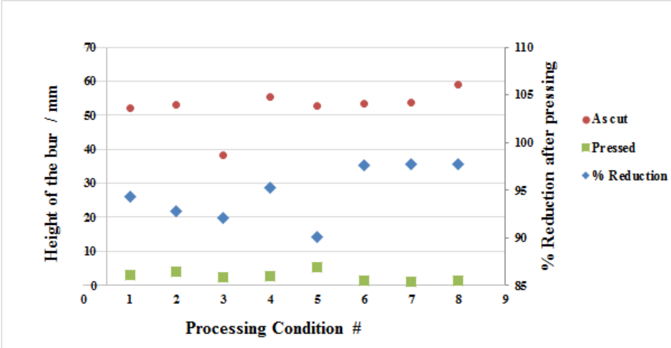

Fig. 3. Burr measurements before and after the pressing step.

The best conditions are those that presented greater decay of the burring value. These conditions are 4, 6, 7 and 8. The fourth condition presented a decrease of height of the burring around 94%, the sixth and the seventh conditions presented about 95% and the eighth condition presented about 97%. The worst conditions are those that presented lower decay of the burring height. These conditions are 2 and 5 and they presented a decrease of height of the burring around 90%. It is clear that all conditions tested reduced the burring height.

In the Figure 4 a cross section of the isostatic holder before and after the pressing process is presented.

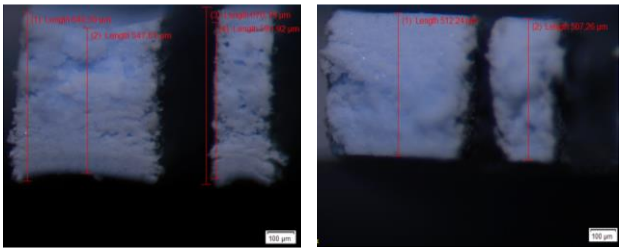

Fig. 4. Bridges cross section before and after the pressing proces.

The planarization effect of the compression is evident, but at the same time it is clearly observed how the width of the beams is affected.

The plots in Figure 5 contain the data about the deformation of the bridges. It shows the bridges width before the pressing (As cut), the width of the bridges after the pressing (Pressed) and the percentage variation of these values (% Deformation) for the eight tested conditions.

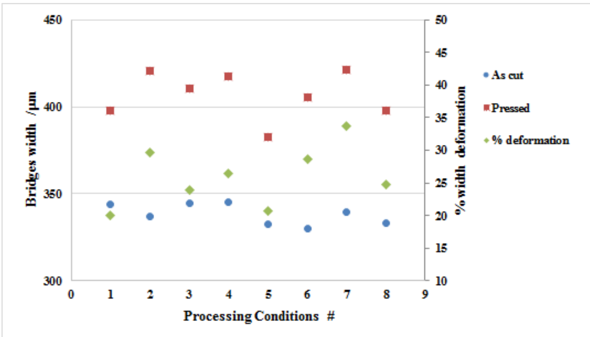

Fig. 5. Bridges deformation before and after the pressing process.

All the conditions tested deformed the bridges, so it is necessary to choose the best tradeoff between burr height reduction and bridge deformation, for that, the perceptual variations were plot in a bi-dimensional map where the lower right most quadrant is the region of interest.

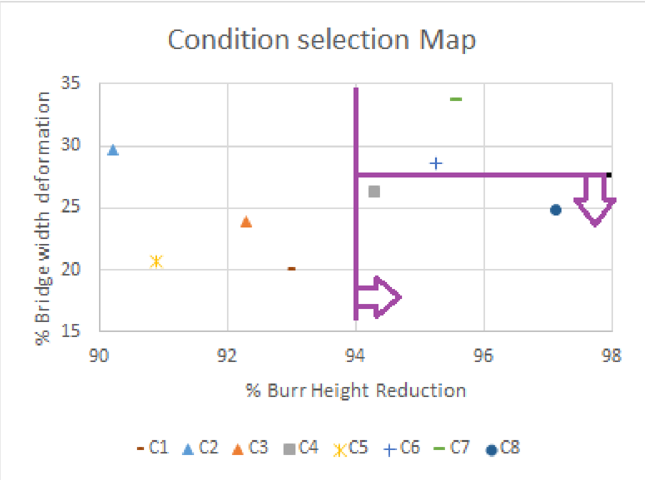

Fig. 6. Burring decrease after the pressing process of condition 4.

From Figure 6 it is clear that conditions C2, C6 and C7 have the highest deformation values of bridges, while conditions C1 and C5 have the lowest deformation values. These conditions presented a bridge deformation value around 20%. However, these conditions are not the best, considering they did not decrease the cutting burr as well as the others. The best conditions that meet the requirements are C4 and C8 and they were selected. The graphics in figures 6 and 7 show the burring decrease after the pressing of the samples in conditions 4 and 8.

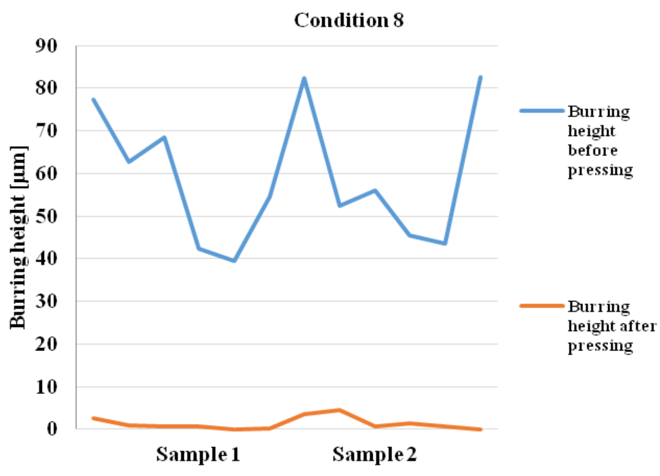

Fig. 7. Burring decrease after the pressing process of condition 8.

After the sintering process, the burring of the two preselected samples were measured again on profilometer and the data about this effect are displayed in the figure 8. It shows the burring height before the sintering (Burring height before), the burring height after the sintering (Burring height after) and the percentage variation of this values (% Δ burring height) of the eight conditions tested.

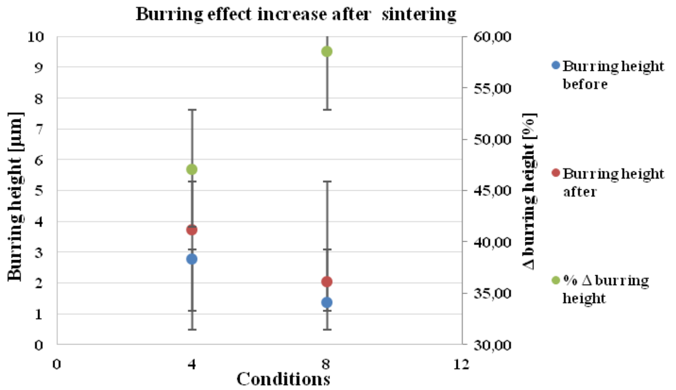

Fig. 8. Burring measurements after the sintering process.

It is possible to observe that after the sintering process, the burring increased in the two conditions measured. An explanation for this effect is that the tape tenders to return to its original position, because its composition contains glass, and this element has the capability to “save” its original configuration, like a “shape memory”. With the heat in the oven, the glass melt and can return to its primary position.

The fourth condition presented an increase in burring value around 48% and the eighth condition presented this value around 59%. The amount of burring that appears after the sintering process is not so accentuated, and in case of Isostatic Holder, it does not represent a big trouble.

Another measurement was made to observe if the bridge deformation changed after the sintering process and the data about this effect are displayed in Figure 9. It shows the bridges width before the sintering (Bridges width before), the bridges width after the sintering (Bridges width after) and the percentage variation of this values (% Δ bridges width) of the eight conditions tested.

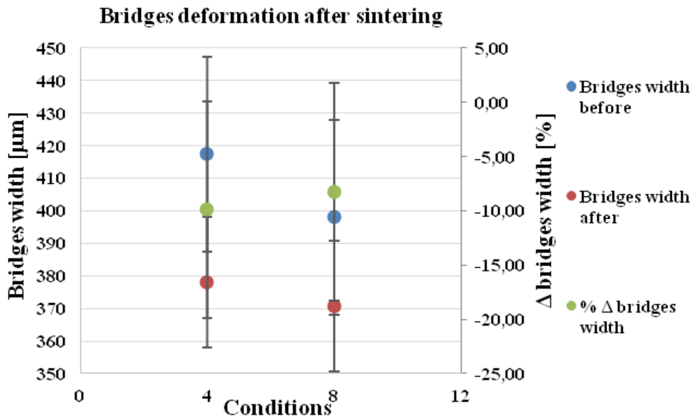

Fig. 9. Bridges deformation measurements after the sintering process.

The fourth condition presented a decrease in bridge deformation value around 10% and the eighth condition presented this value around 8%. This fact was expected after the analysis of burring values after sintering process.

The figure 10 shows the changes suffered by the peaks of a pressed and sintered sample using the condition number 8.

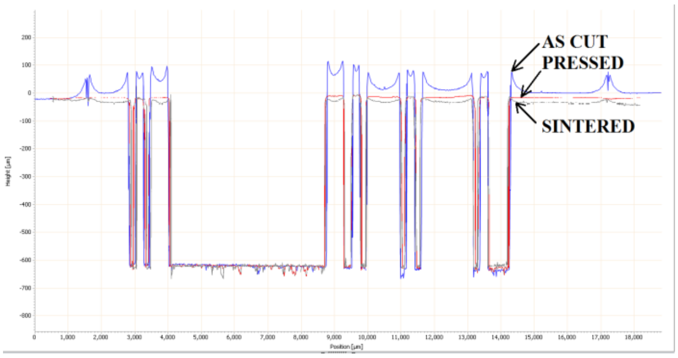

Fig. 10. Bridges deformation after the pressing and sintering processes.

IV. CONCLUSIONS

All the pressing conditions tested decreased the height of the burring, although they deformed the bridges. The best conditions that decreased the burring and presented the lowest values of bridge deformation were the conditions 4 and 8. After the sintering process, it was possible to observe that some of the burring reappeared in all samples, because the capability of glass to returns to its original position. This phenomenon does not cause problems to the project. After analyzing all results, it is possible to affirm that the best pressing condition is condition number 8, because this condition decreased the burring height in 97% and, at the same time, it did not deform so much the bridge, around 25%.

V. ACKNOWLEDGMENT

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VI. REFERENCES

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