THE TECHNOLOGY OF CERAMIC PACKAGES

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Abstract: This paper deals with the technology of ceramic packages. The first part is about ceramic in general. The next part is focused on used material Nabaltec and advantages of this type of technology i.e. ceramic powder pressing followed by the milling of the pressed ceramic and shows disadvantages of this technology step. The inspection was done by SEM pictures and shows the difference between sintered and unsintered ceramic. The last part is a simulation with 120mW power load and shows temperature distribution on the ceramic package compared with mold compound as the packaging material.

Keywords: ceramic, packaging, sintering, simulation

1 INTRODUCTION

The ceramic material is one of the oldest material used by mankind. But this material can offer many uses in nowadays. In the electronics industry, the most required attribute is reliability. In the sphere of the military or medical industry is necessary used high-reliability material not like in common electronics. The main requirements are hermeticity, toughness, dielectric properties, and acid resistance. This attribute is fulfilled by the ceramic which have extraordinary properties. For this research, it was chosen a corundum ceramic. The corundum ceramic is the second toughest mineral and has good properties for packaging (chemical resistance, hermetic and high-frequency use).

Figure 1: Corundum powder and sintered parts [1]

For purpose of this paper was chosen Nabaltec 9620F corundum powder figure 1. This material is from 96% Al_2O_3 powder and 4% additives which are evaporated during sintering. The technology of ceramic packaging is a sophisticated process. The main issue of sintering ceramic is shrinkage, which is approximately 10 – 20% of the volume. The main types creation of ceramic package are ceramic mold casting, ceramic powder pressing, and the last one is high temperature co-fired sheets. This paper is focused on the second one technology ceramic powder pressing. This technology consists of two parts which are powder pressing and sintering. The main problem is the price of tools for pressing. And it's difficult pressing complicated structure. The easiest way is pressing round or rectangular shape and then machined by milling cutter and get required shape. [2,3]

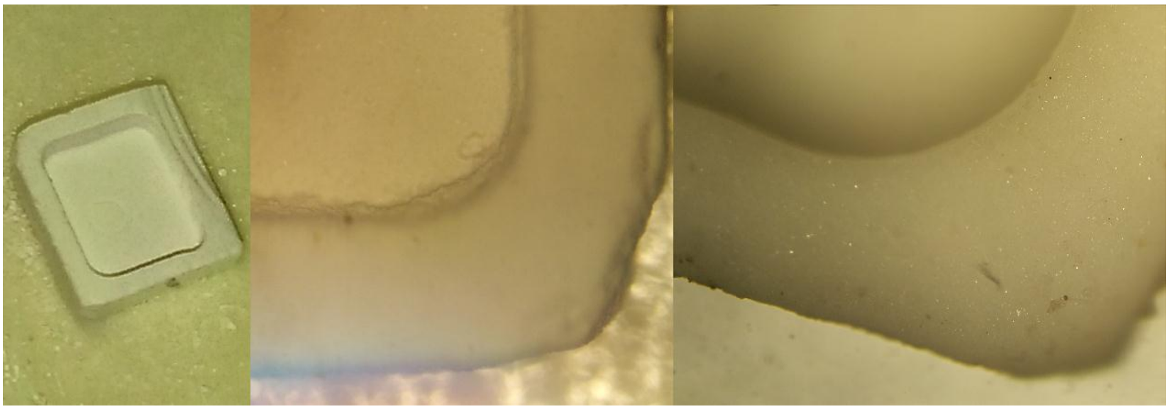
The sintering is sophisticated process due to the melting point of corundum is 2044 °C. The principle of the sintering is melting the edge of corundum granule not all volume of granule but only the edges and combinate these granules in all volume. Due to this technology sintering is possible at a lower temperature than the melting point is. The highest temperature used for the sintering was 1650 °C. The producer of this ceramic powder recommended sintering profile about (17–36) hours long.

2 EXPERIMENTAL PART

The first part of experimental work was set new sintering profile for a smaller amount of powder ceramic volume. For testing is necessary to create samples. For our purpose was created 20 samples. For verification was used many types of samples with different weight and shape for testing sintering profile. It is necessary to realize many types of shape and weight and find applicable window. This profile is useful for ceramic with weight up to 20g and 40mm diameter. The important part of the testing was powder pressing. The producer recommendation is 100MPa for the best sintering. For testing was creates two round shape with 10 mm and 40 mm diameter.

After pressing it was necessary to mill the samples to final shape. The pressing tools are very expensive and it is the cheaper pressed simple shape and milled to final shape like package for IC´s. Milling brittle material is difficult and success was 85%. The left samples were damaged. The consistency of pressed samples was as chalk. The figure 2a shows milled package with 6 x 5 x 1 mm dimension.

The figure 2b shows unsintered milled package. The edges are much damaged but it does not defect. The figure 2c shows sintered package and damaged edges are in good condition. The sintering process repairs small defect in the creation of package by milling. The milling is not a good part of this technology and it necessary for better and precisely package used another technology to get the appropriate package.

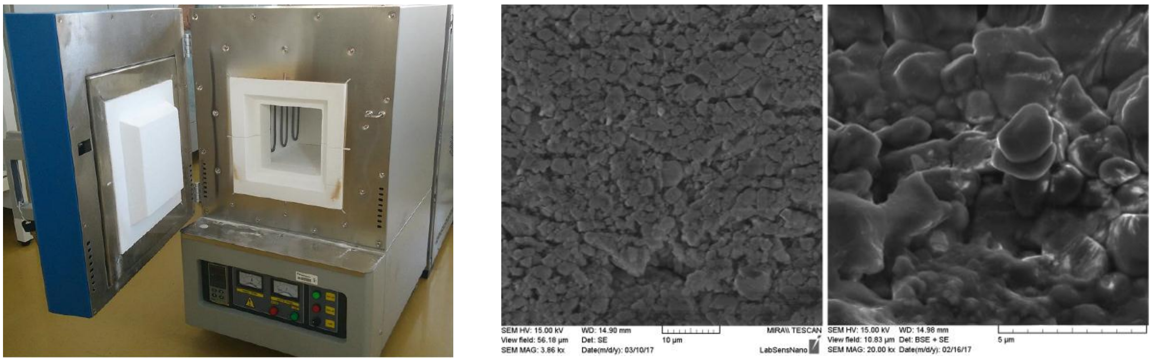


a) b) c)

Figure 2: a) Pressed package b) Detail of milled package c) Detail of sintered package

The sintering profile set by the producer is for large production and high amount of volume. The first part was set sintering profile for a small volume of corundum ceramic and get shorter sintering time. For sintering was used furnace ST 1700MX shows figure 3a. The sintering profile was (22 – 300) °C in ten minutes. This part is the most important due to evaporating additives. When this period is too short and additives are not evaporated, the ceramic can crack. The second part is 10 minutes hold at this temperature. The next part is (300 – 1600) °C in 130 minutes and holds on temperature 1600 °C for 30 minutes. The last part and the longest is cooling. The ceramic must be cooled by slow temperature gradient about 60 °C per 50 minutes.

After sintering it is difficult to test the quality of sintered ceramic. For the purpose of this paper, we used scanning electron microscope (SEM). This type of inspection is accurate for divide good or bad sintering. Figure 3a, b shows a picture from SEM, figure 3b is unsintered ceramic and it is possible to see sharp edges between granulates. Figure 3c shows a picture of sintered ceramic and edges of corundum granulate are sintered well.



a) b) c)

Figure 3: a) Furnace ST 1700MX, b) unsintered corundum powder, c) sintered corundum powder

Figure 4: Chamber of furnace after sintering

The figure 4 shows chamber of furnace after sintering. It can be seen that the ceramic substrate as underlay it wasn't right choice. The ceramic substrate was bended and some of packages was stick to the substrate.

The last experimental part was set to power load of the package. For this purpose, was used ANSYS Workbench 16.1. The steady-state thermal simulation was performed to obtain a result. The package was set as Alumina 96% with 3684,2 kg.m^{-3} density, 8,1x10^{-6} coefficient of thermal expansion, young modulus 3x10^{11} Pa, 0,2093 Poisson's ratios, 1,72x10^{11} Pa bulk modulus, 1,21x10^{11}

Pa shear modulus, 25 W.m^{-1}.C^{-1} and specific heat was 880 J.kg^{-1}.C^{-1}. Figure 5 shows temperature distribution with 120mW power load. It can be seen that temperature on the chip is 82,139 °C and on the surface of the package is 80 °C. The difference between temperatures through the package is 2,139 °C.

Another simulation was done with difference material. The package was set as mold compound as the common package material. The temperature in the chip was 116,46 °C and at the bottom of the package was 60,509 °C. The difference was 55,951 °C through the package. These simulations show how high thermal conductivity of corundum ceramic is and how important this attribute is for packaging.

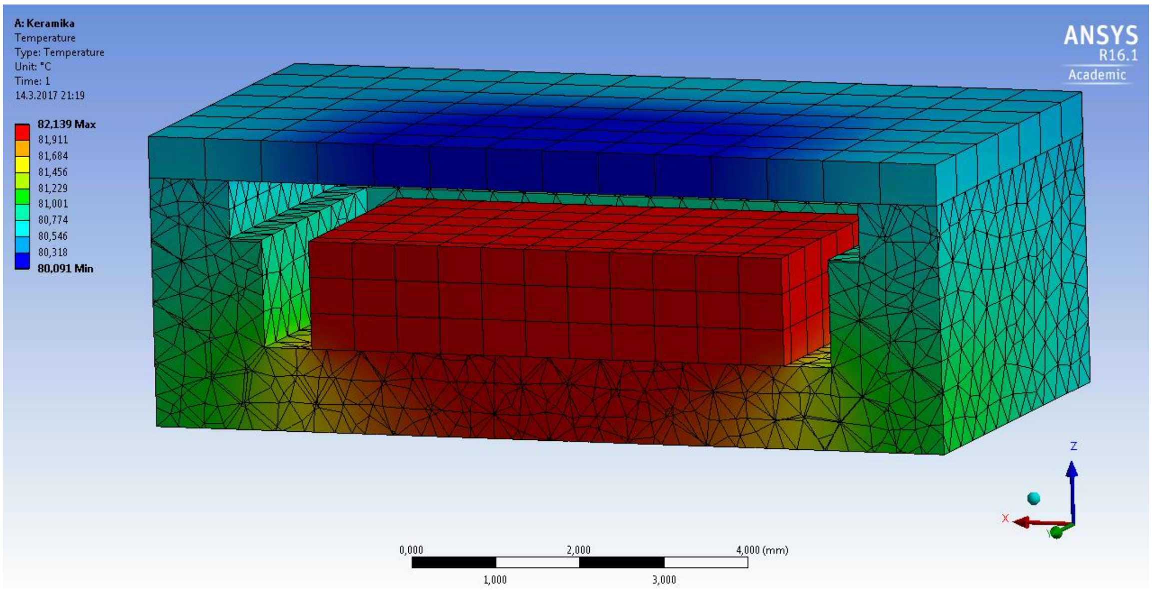


Figure 5: Temperature distribution with 120mW power load.

3 CONCLUSION

This paper shows technology of ceramic packaging and describes advantages and disadvantages of this technology. The experimental part consists of setting new sintering profile suitable for a smaller package and lower amount of volume.

The next part is dedicated to describing disadvantage of milling the pressed ceramic. In this step it will be better to replace with difference technology or to use better pressing tool with final shape. The inspection is necessary for ceramic sintering. The figure 2b and 2c show main difference between sintered and unsintered ceramic powder. This technology is very difficult and is not yet ready to high production. This area will be part of the following research.

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