COMPARATIVE ANALYSIS BETWEEN DIFFERENT TECHNIQUES FOR POROSITY MEASUREMENT APPLIED TO HIGH HARDNESS ADVANCED CERAMICS

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1 Introduction

The search for high mechanical performance materials aroused great interest in the research and development of advanced ceramics such as silicon carbide (SiC). However, the porosity is still seen as a performance limiting factor of these. This work aims to quantify the porosity through analysis and digital imaging (DIP) obtained by optical microscopy with control of grinding and polishing parameters along various depths of advanced ceramic, followed by stacking these images through a 3D module to analyze the three-dimensional behavior of the pores. The methodology will be compared to the Archimedes method and computed tomography. The present results show that the DIP technique for the type and distribution of the pores existing been successful to a hard material characterization.

Silicon carbide (SiC) is highlight of ceramic class. This material has excellent mechanical properties at low and high temperatures, high wear resistance, high thermal stability and corrosion resistance. The unique characteristics of silicon carbide allow it to be used in various structural applications [1].

Some problems still limit the scope of silicon carbide, and other ceramic in general. The high cost of the manufacturing process, the difficulty of sintering and the control of porosity, together with the difficulty of more complex geometries. There are effective techniques for evaluation and quantification of the existing porosity in advanced ceramics, such as computed tomography, however, these techniques require high equipment and handling costs, which led to the search for alternatives that provide equally safe and less costly results, as quantitative stereology using the Digital Image Processing (DIP).

2 Methodology

Until now we used three samples $10x10x11$mm provided by ESK manufacturer, Ekasic F group [1]. These samples were submitted to Archimedes procedure for density measurements, according to the NBR 6220 ABNT [1]. They were embedded, ground and polished in nine layers (100, 200, 500, 1000, 2000, 3000, 4000, 5000 and 6000 uM) for obtaining optical microscopy images throughout the material. Following collection were 108 images of the surfaces of samples with an optical microscope (MO) Olympus BX60M, 36 for each sample (04 in each of the nine sections) in different regions of the surface. All were collected under 100x magnification.

The digital image processing was carried out through AxionVision software [1]. All images were processed individually and involved steps of preprocessing, segmentation and feature extraction. There was no need to eliminate "noise" and lighting correction for generating bimodal histograms for images.

3 Results and Discussion

Being commercial samples, the manufacturer claims that the degree of porosity of the material is less than 2.0% of its volume and its density is 3.15g/cm^3. Figure 1 illustrates an image obtained by MO 100x magnification with a depth of 100 micrometres. The result after the segmentation step for extracting attributes and quantifying the number of pores present in the material is shown in Figure 2. In turn, Figure 3 is an image optical microscope with a magnification of 500x at a depth of 200 micrometres . The result of their digital processing is shown in Figure 4. Table 1 shows the silicon carbide densities obtained by the Archimedes method. Comparing the density obtained by this method with the theoretical value in this literature, a comparison is made where the difference between the values is the number of pores present in the material. Table 2, in turn, shows the porosity values obtained using the DIP

Porosity of sample 01 (%)	0.622
Porosity of sample 02 (%)	0.606
Porosity of sample 03 (%)	0.579
Average porosity of the material (%)	0.579

Table 1: Average porosities of three samples and SiC as a whole.

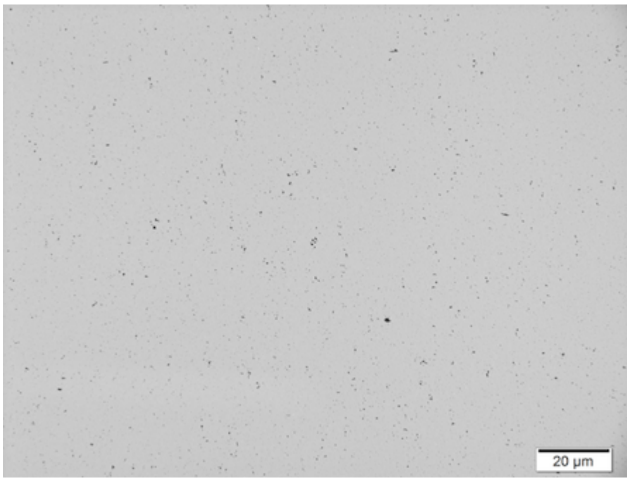

Figure 1: Optical microscopy image of SiC sample with 100x magnification after sanding and polishing at a depth of 100μm.

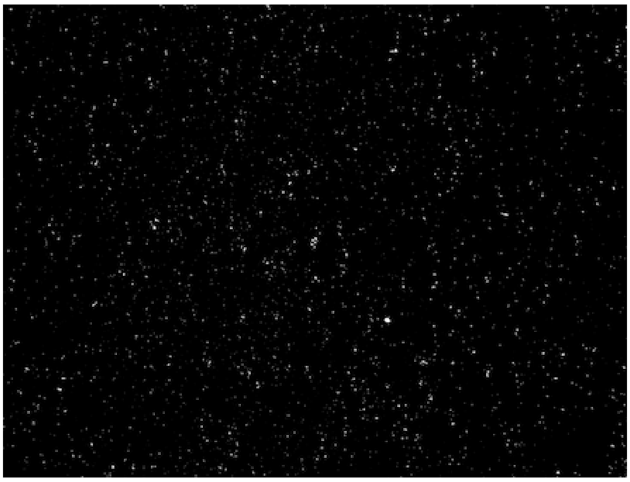

Figure 2: Same image in Figure 1, but after digital processing to identify and quantify the presence of pores.

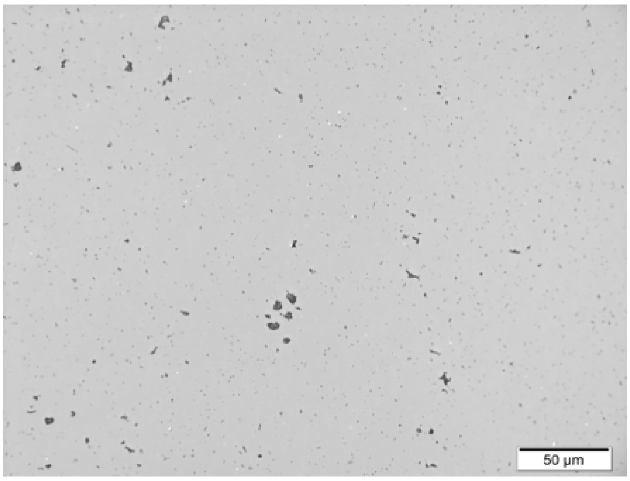

Figure 3: Optical microscopy image of SiC sample with 500x magnification after sanding and polishing at a depth of 200μm.

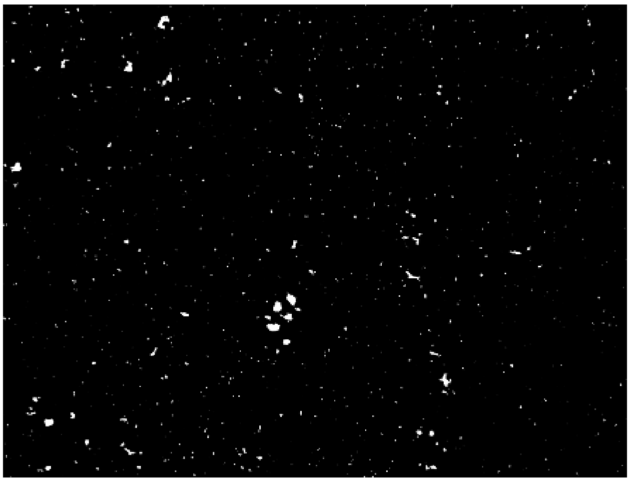

Figure 4: Same image in Figure 3, but after digital processing to identify and quantify the presence of pores.

Bulk density (g/cm^3)	Relative Density	Relative Density (%)
3.09	0.98	98.09
3.15	1.00	100.00
3.16	1.00	100.00
3.17	1.00	100.00
Average Porosity (%)	0.48	0.82

Table 2: Measurements of relative and apparent densities of SiC by Archimedes method.

4 Conclusions

It was found that the percentage porosities found for the methods of Archimedes and PDI showed a great similarity (0.48%±0.82 by Archimedes and 0.6%±0.018 per PDI) and did not exceed the 2.0 limit % stipulated by the manufacturer for ESK lot Ekasic F SiCa detailed procedure has been prepared that will serve as guide for future research. The Digital Image Processing had credibility stated for the tested samples, proved to be a suitable method which is based on quantitative metallographic procedures.

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References

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