



The Effect of Surface and Heat Treatments on Phase Composition, Crystal Size, Strain, and Topography of high cubic zirconia Material: A pilot study

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Purpose:

To investigate the effect of different surface and heat treatments on the phase composition, crystal size, strain, and topography of high-cubic zirconia (5Y-TZP).

Introduction:

5Y-TZP has improved esthetic but lacks the transformation toughness phenomenon observed with conventional zirconia (3Y-TZP). As a result, It has reduced flexural strength but is more resistant to low thermal degradation. However, there is scarce information about cubic crystal's response to external stress applied through surface and heat treatment.

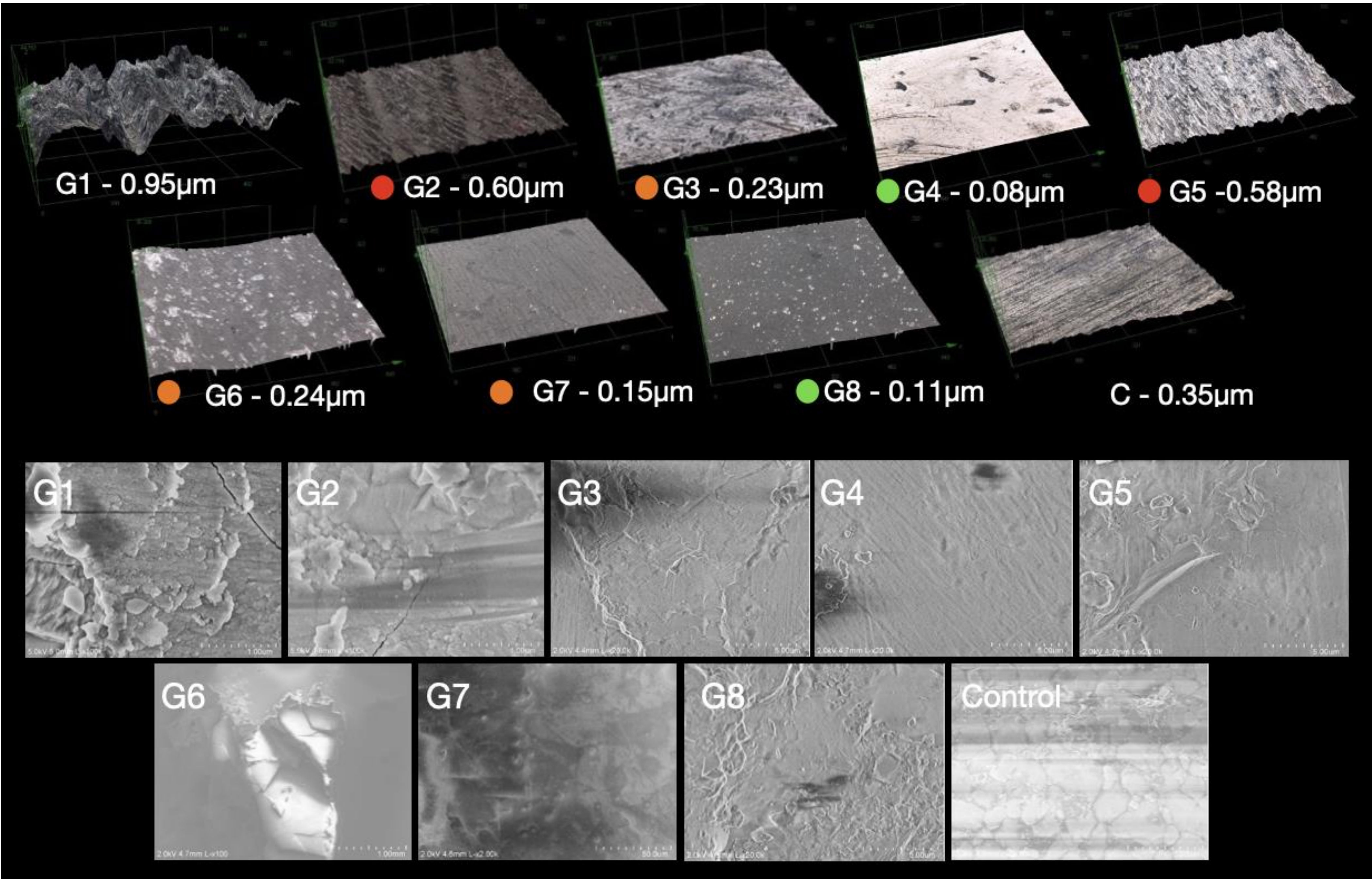
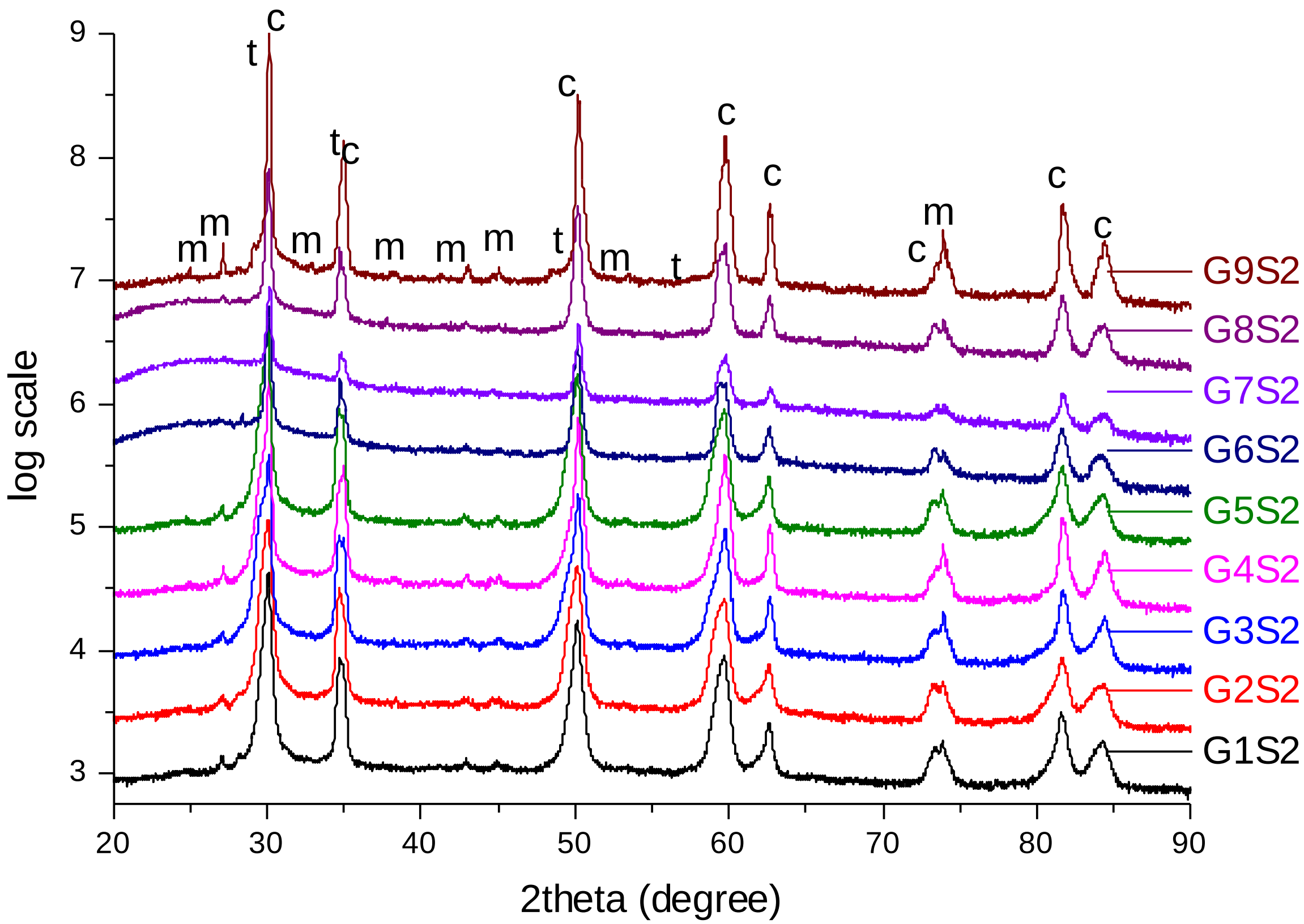
Methodology:

Twenty-seven 5Y-TZP (Prettau Anterior) discs (1.18 mm x 12mm) were milled and sintered. Different surface and heat treatment protocols were applied resulting in 8 experimental groups and one control group (table). Surface roughness and topography were analyzed with a 3D optic profiler (crystallography, and surface elements were analyzed with SEM & EDS (Bruker). Phase composition and quantification, crystal size and strain were analyzed with X-ray diffraction and Rietveld refinement.

Results:

- The diffraction peaks and phase composition of the different groups (Fig.1). Monoclinic phase was detected in all groups in same amount (3-4 wt%).

Groups	Cubic wt% Mean ±SD	Cubic Crystal Size (nm) Mean	Cubic Strain %
1. GC	44 ± 19	81.5	1.35
2. GF	58 ± 35	148.7	1.92
3. GF+P1	45 ± 25	118.3	4.8
4.GF+P1+DP	55 ± 32	228.7	2.5
5. GF+P2	52 ± 27	174.4	0.7
6. GF+GI	19 ± 8	71.5	1.5
7.GF+ P1+GI	32 ± 32	91.3	1.1
8. Al2O3	38 ± 28	76.1	1.2
9. C	88 ± 2	431.3	0.2



- XRD patterns for experimental groups showed broaden peaks with decreased intensity.
- Cubic crystals decreased in quantity and size with increased strain for all experimental groups.
- Surface roughness and topography are shown in Fig.2, crystallography is shown in Fig.3.
- O (43 at. %), Zr (22 at. %), C (32 at. %) and Y (2.5 at. %) were the main surface elements detected in G1-G5, comparable to the control.
- G6-8 were associated with amorphous phase of different surface elements. (G6 and 7: O, Si, C,Na, Al, K, Ca, Zr, G8: O, C, Zr, Y, Al).

Discussion:

- The wide XRD peaks and reduced intensity in the experimental groups indicate the cubic crytals distortion or tranformation into rhombohedral phase in response to stress. Such tranformation was reported to be associated with about 3% expansion. XRD analysis should account for this phase.
- The preferential orientation phenomena, and the overlapping between cubic and tetragonal crystals are the main limitations of the XRD and Reitveld refinement analysis.

Conclusions:

- The applied surface and heat treatments to cubic zirconia resulted in different topography, crystallography and surface elements.
- Cubic zirconia showed crystal changes suggesting the presence of rhombohedral phase as a response to stress.

References

