MEDNARODNA PODIPLOMSKA ŠOLA JOŽEFA STEFANA

JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL

Biscuit – sintered zirconia ceramics for dental applications

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Background photograph shows dental posts made in Slovenia:

SiPOST

Introduction:

Yttria-stabilized tetragonal zirconia (Y-TZP) has become increasingly popular as an alternative high-toughness core material in dental restorations because of its biocompatibility, attractive mechanical properties and its superior natural appearance compared with metal - ceramic restorations. The available literature data suggest that the differences in the elastic moduli (E) between zirconia and dentine result in stresses at their interface that increase the possibility of a marginal seal failure.[1] As a consequence, this can lead to the development of secondary caries and/or periodontal disease. For such applications, novel dental materials exhibiting lower elastic modulus than currently available are being developed.

Objectives:

- to reduce elastic modulus of Y-TZP ceramic while preserving its useful flexural strength (σ)
- to evaluate mechanical properties of biscuit sintered nanostructured Y-TZP ceramics

Methods:

The so-called core-shell concept was adopted for the preparation of the starting materials.[2, 3] This concept exploits homo-aggregation, which results in a uniform distribution of nanosized particles attached to the surface of the submicron-sized particles in the slurry. After the slip casting, the green pellets were biscuit-sintered at various temperatures in the ambient air in order to obtain moderately porous zirconia samples.

•materials:

	Y_2O_3, mol%	BET, m^2/g	crystallite size (nm)	pH	solids content (wt%)
TZ-3Y* (Tosoh)	3	15.4	28	/	/
XZO 1356/01* (MEL chemicals)	3	/	11	3.2	22-30

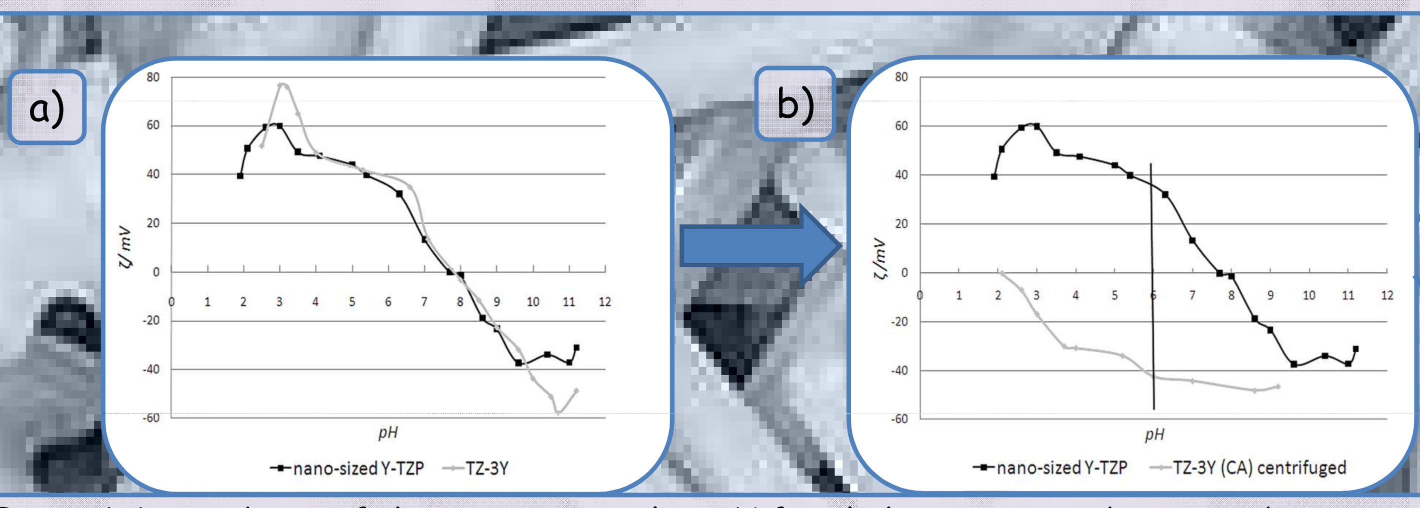

Figure 1: Dependence of the zeta potential on pH for a) the as-received nano- and micron-sized Y-TZP suspensions and b) for the combination of the surface-modified micron-sized Y-TZP and unchanged nano-sized Y-TZP suspensions. The vertical line indicates the pH at which the core-shell material was prepared.

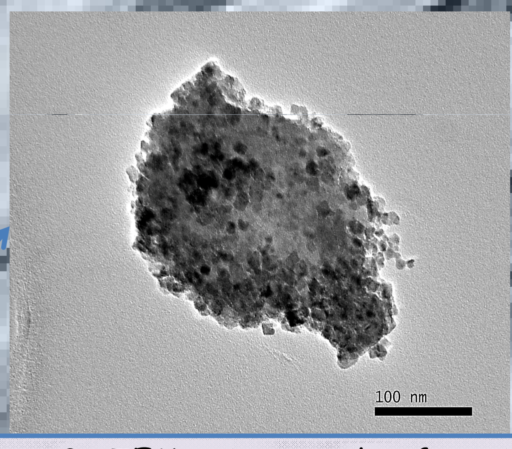

Figure 2: TEM micrograph of a single TZ-3Y core-particle coated with nano-sized zirconia particles.

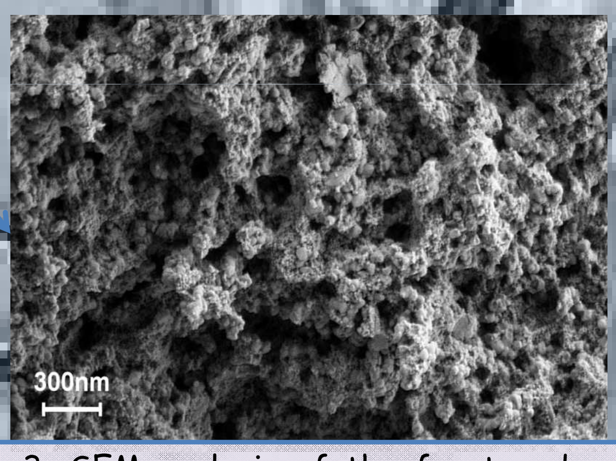

Figure 3: SEM analysis of the fractured surface of the slip casted pellet shows homogeneous distribution of shell particles through the whole thickness of the green sample.

Results:

- densification and mechanical properties of biscuit-sintered nanostructured ceramics:

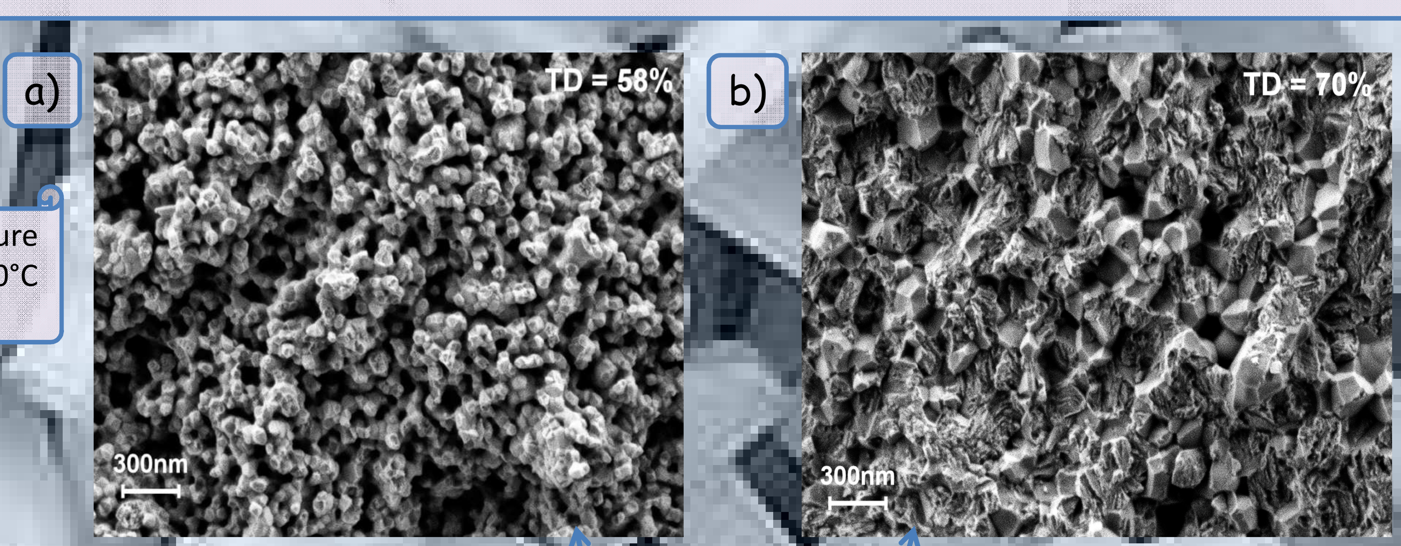

Figure 4: FEG-SEM analysis of fracture surface of the sample a) sintered at 1100°C and b) sintered at 1300°C.

•characterization:

✓zetapotential analysis
✓fractional density
✓biaxial flexural strength
✓TEM and SEM analyses

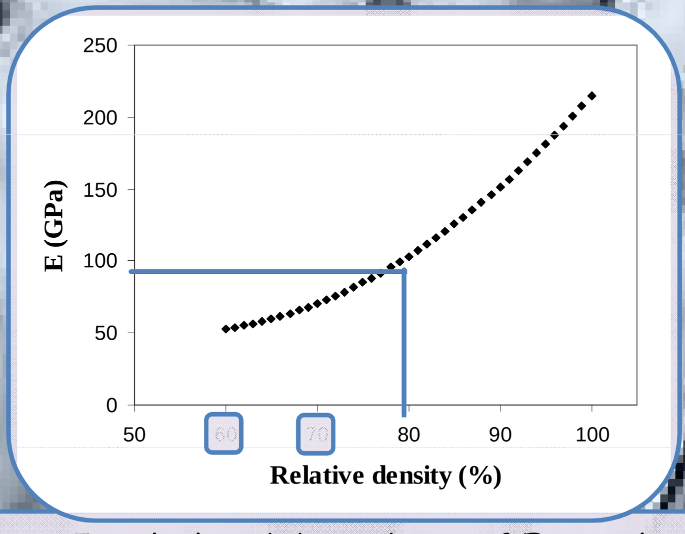

Figure 5: Calculated dependence of E vs. relative density.

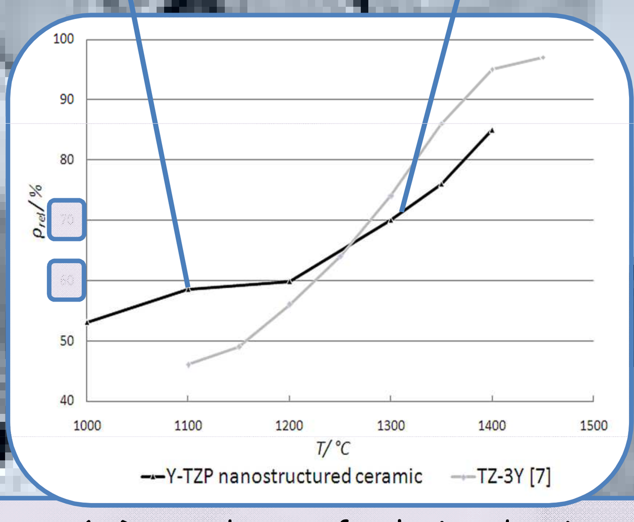

Figure 6: Dependence of relative density vs. temperature.

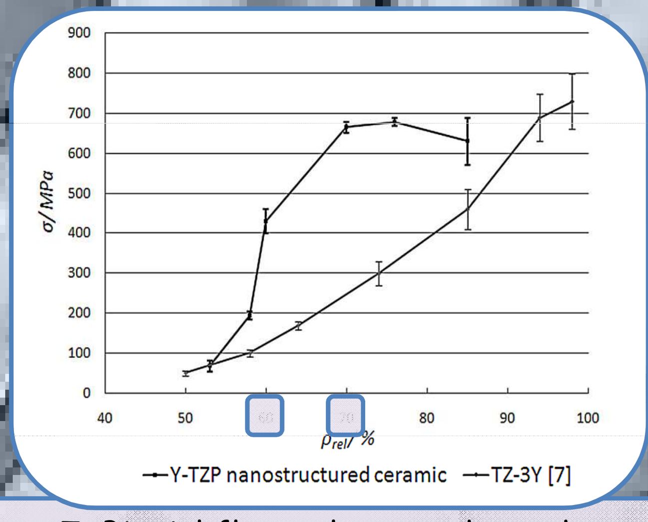

Figure 7: Biaxial flexural strength vs. theoretical density for nanostructured ceramics along with comparison curve of biscuit-sintered TZ-3Y powder.

Conclusions:

The remarkable increase in strength is related to the larger area of the interparticle contacts.[4] The addition of the nanoparticles enhances the formation of necks between the nanosized and/or the submicron-sized particles. At a TD of 70% the flexural strength almost doubles with respect to the conventionally used dry-pressed submicron-sized Y-TZP powder.[5]

References:

1. M. Guazzato, I. Ichim, M.V.Swain: IXth ECERS (2005), Book of abstracts, p.207
2. F. Caruso, Nanoengineering of particle surfaces, Nanoengineering of particle surfaces, Adv. Mat., 13, No.1, (2001)
3. M. Cerbelaud, A. Videcoq, P. Abelard, C. Pagnoux, F. Rossignol, R. Ferrando, Heteroaggregation between Al_2O_3 submicrometer particles and SiO_2 nanoparticles: Experiment and simulation, Langmuir, 24, 3001-3008, (2008)
4. D. Hardy, D. J. Green, Mechanical properties of partially sintered alumina, J. Eur. Ceram. Soc., 15, 769-775, (1995)
5. S. Perko, A. Dakskobler, T. Kosmac., High performance porous nanostructured ceramics, In press, J. Am. Ceram. Soc. (2010)