Commission for Technology and Innovation CTI

SPT small precision tools

Empa Materials Science and Technology

HIGH STRENGTH ALUMINA

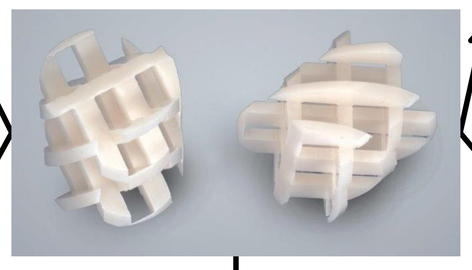
Goal

- Decrease dimensions of aligner (- 20 %)
- Stronger (≥ 20 %)
- Similar optical quality

Product with smaller geometry

Challenge

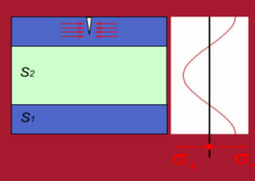
- Complex shape
- High flexural strength
- Material fixed
- Appearance
- Green body preparation fixed



Approach

Compressive layer by:

- Solid state reactions
- Glass layer



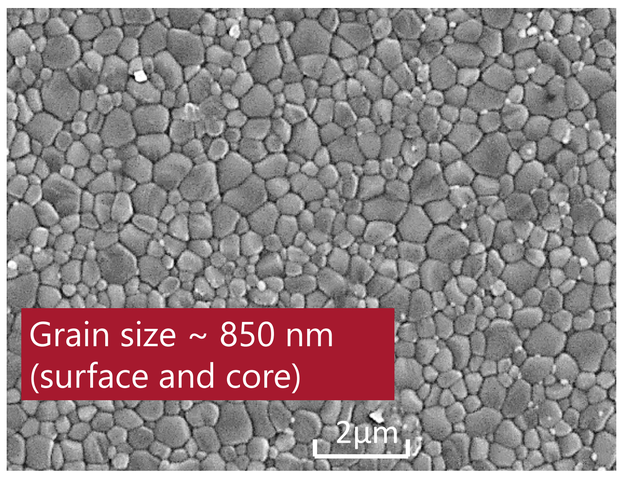
$$\varepsilon_M = \int_T^{T_2} (\alpha_2 - \alpha_1) dT$$

Chemistry modification

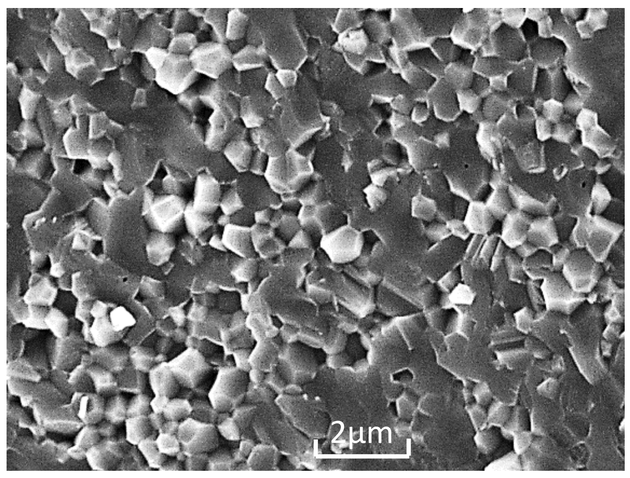
State of the Art

- Pure alumina powder
- Injection moulding
- Sintering in air
- Hot isostatic pressing (HIP)

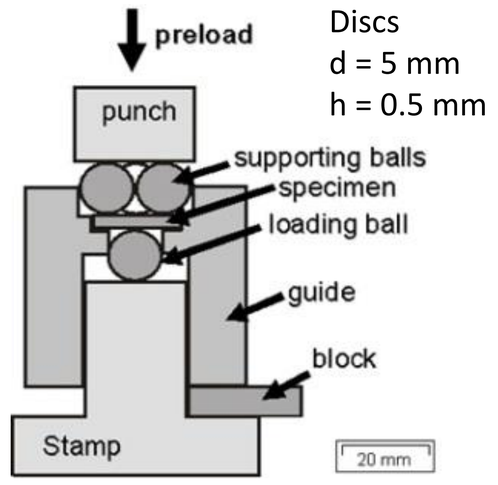
As sintered surface



Fracture surface at core



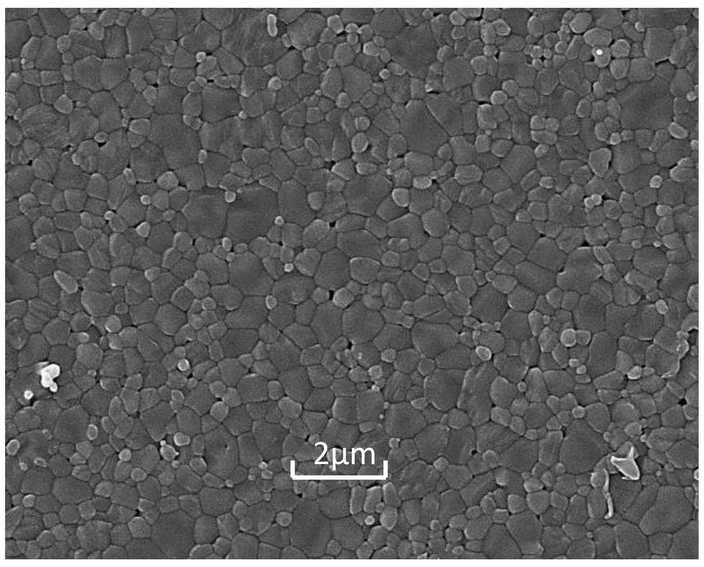
B3B flexural strength

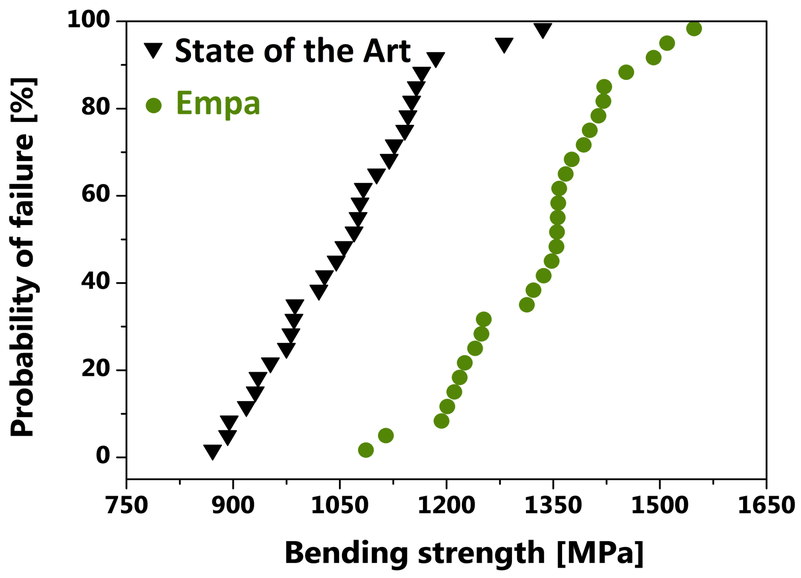


Modification of grain boundary chemistry

- PPM of impurities in material (Mg, Si, Fe, Na)
- Segregation to grain boundaries
- Suppress glass phase formation at grain boundaries
- No oxygen, no carbon

High vacuum sintering





σ_0 = 1108 MPa
m = 9.6
Max. = 1335 MPa

σ_0 = 1379 MPa
m = 13.7
Max. = 1548 MPa

Sintering in high vacuum

Conditions

- High vacuum of ≥ 10^{-5} mbar
- 99.9 % pure alumina tube
- Embeddment of samples into pure alumina powder
- Avoiding any possible contamination

Results

- ✓ **Increase of flexural strength**
- ✓ **Unchanged opacity**
- ✓ **Economically applicable process technique**

Project team

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Scientific publications

1. M. Michálek, M. Michálková, G. Blugan, J. Kuebler, Effect of carbon contamination on the sintering of alumina ceramics, J Eur Ceram Soc 38 (1) (2018) 193-199.
2. M. Michálek, M. Michálková, G. Blugan, J. Kuebler, Alumina with a strength above 1 GPa – accepted in Ceramics International.
3. M. Michálková, M. Michalek, G. Blugan, J. Kuebler, Influence of spinel and magnesia powder bed on mechanical properties of alumina sintered under air and nitrogen atmosphere – submitted.