IPS e.max Zirconia

Scientific Background

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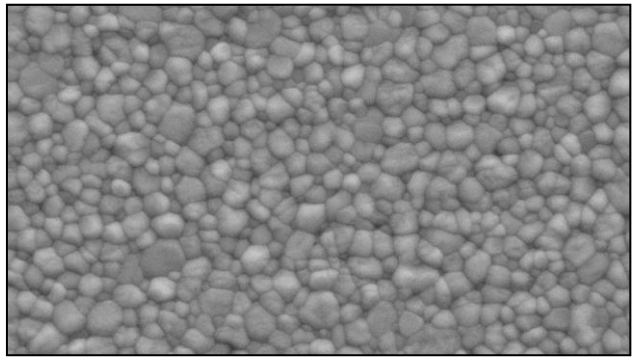
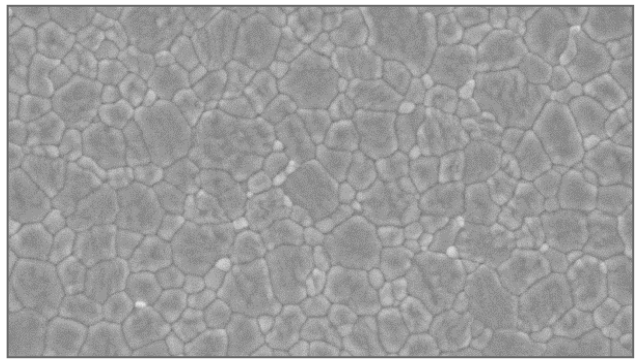
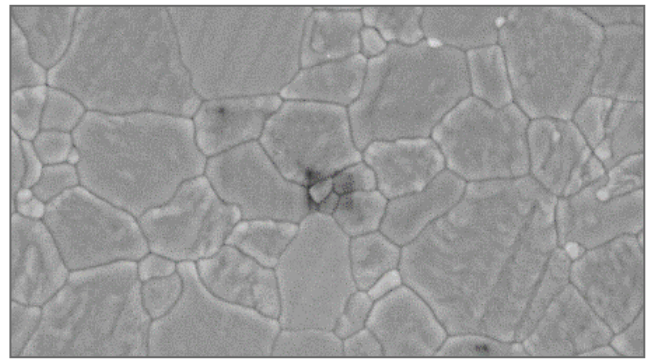
Zirconia - Chemical Composition: **Y**:ZrO_2

3Y-TZP (3 mol.%)	**4Y-TZP** (4 mol.%)	**5Y-TZP** (5 mol.%) **«Zirconia Anterior»**
4.5 – 6.0 wt% Y_2O_3 100% tetragonal*	6.5 – 8.0 wt% Y_2O_3 ~75% tetragonal + ~25% cubic*	9.0 – 10.0 wt% Y_2O_3 ~50% tetragonal + ~50% cubic*

Tetragonal phase is essential for transformation toughening (t ⇨ m), which results in high **fracture toughness** and **strength**, **Cubic** phase for **enhanced translucency** by **less grain boundary scattering**.

* Simplification: latest research shows different numbers and additional *t'* phase

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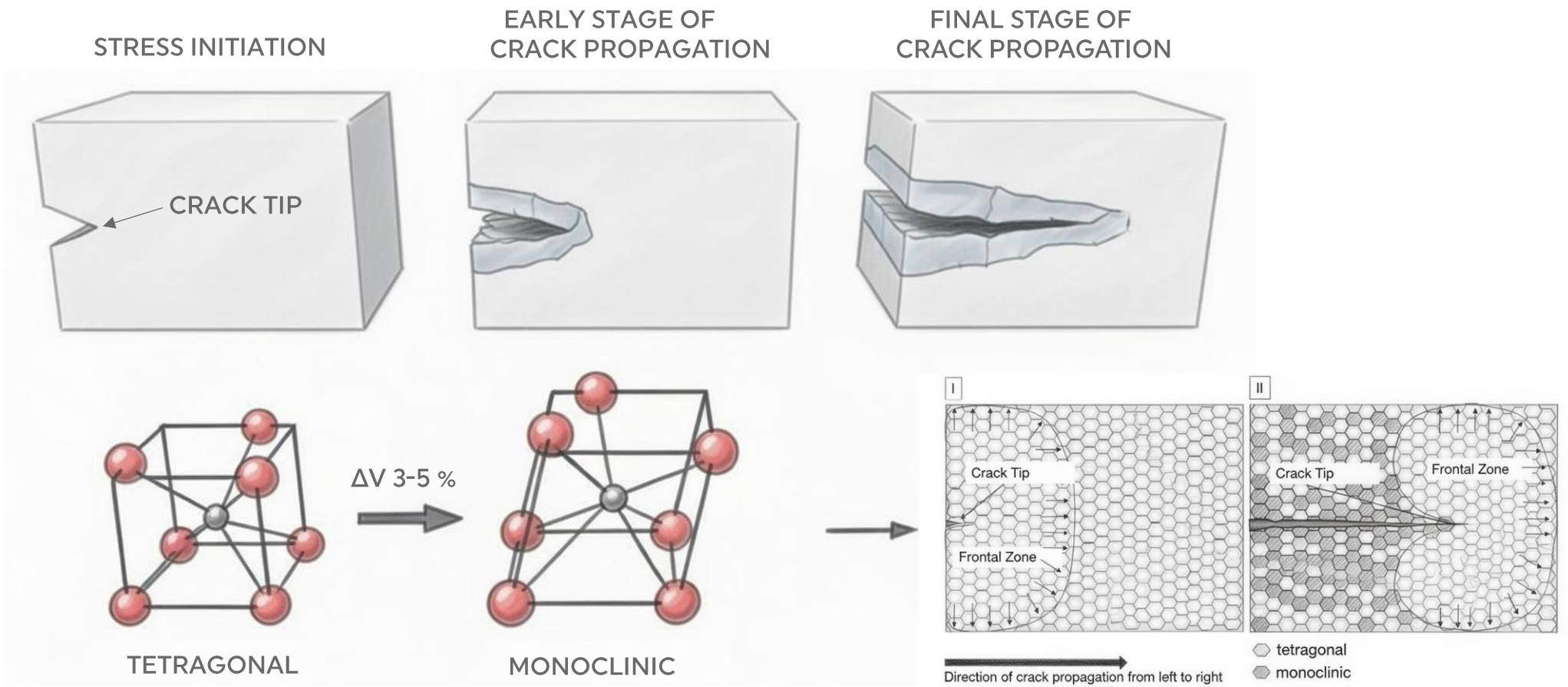
Zirconia - Transformation Toughening of $Y:ZrO_2$



Tetragonal phase is essential for transformation toughening (t ⇨ m)

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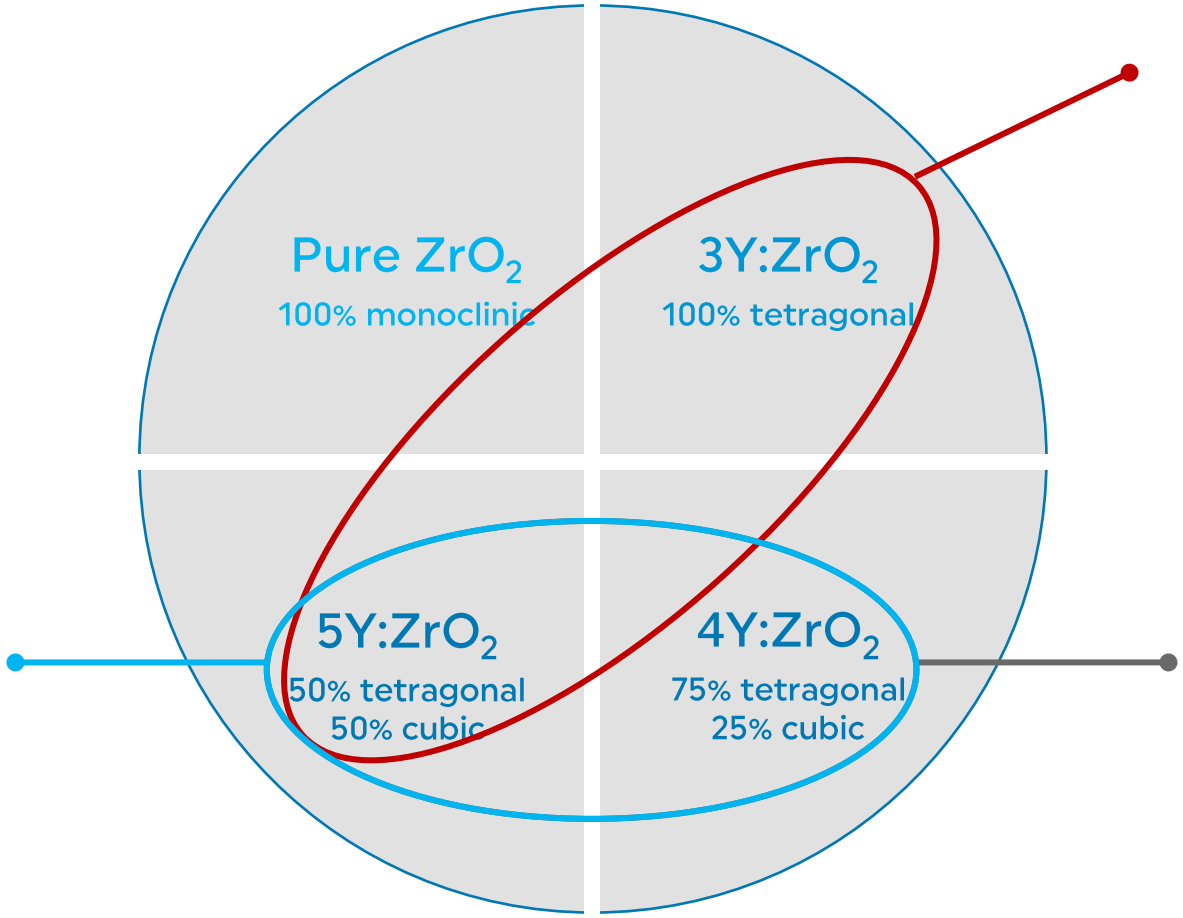
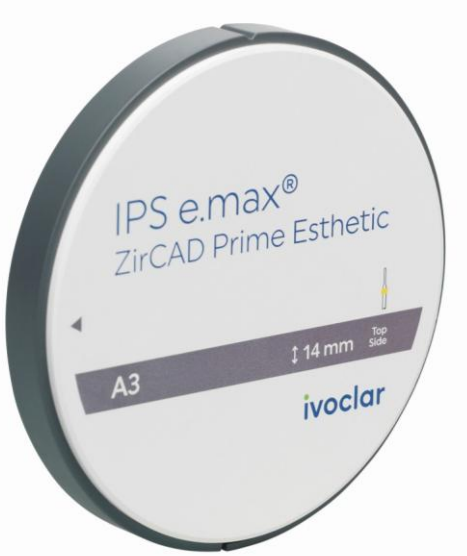
IPS e.max Material Grades and Products

Transformation toughening is zirconia's built-in "self-defense" against cracks

IPS e.max® Zirconia





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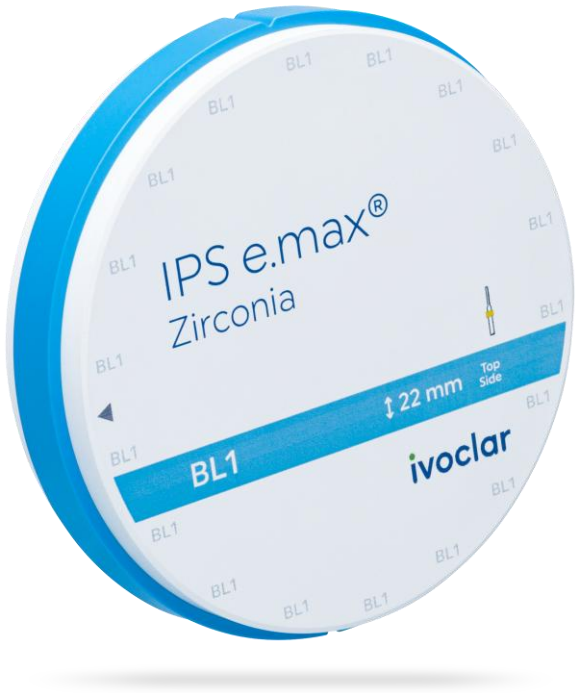
Does this mean all zirconia products are the same?

(unfortunately) No

- Chemical composition determine what's possible
- Production process determines what's real

IPS e.max Zirconia Production Process

IPS e.max Zirconia - the concept behind



- NEW generation of zirconia raw materials
- Improved GTx Technology Manufacturing Process
- FOCUS on clinical performance:
  - Highest esthetic
  - Maximum versatility
    - from single crown to full arch restorations
    - for infiltration, stain & glaze, cut-back.
  - Increasing zirconia workflow efficiency

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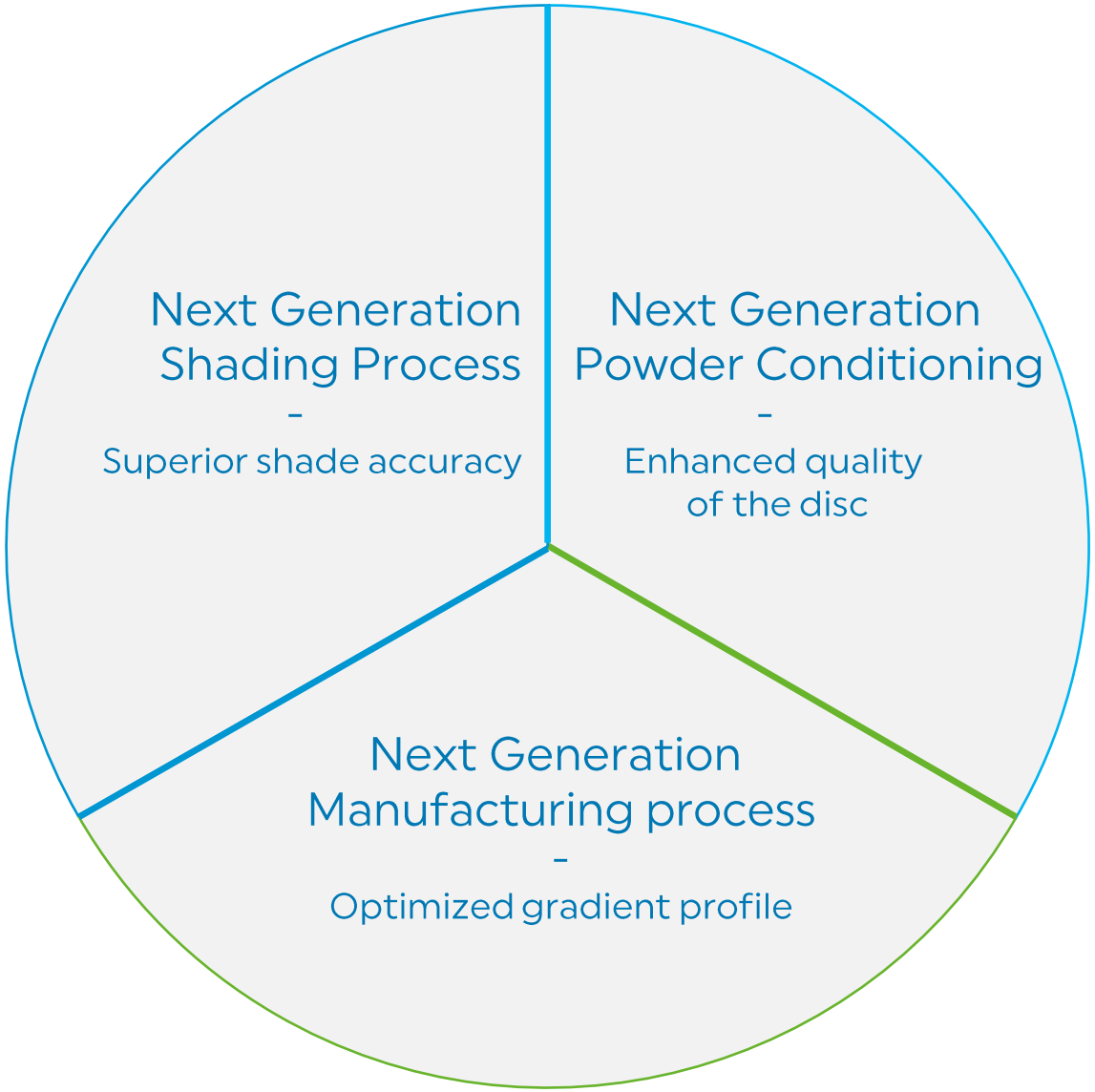
IPS e.max Zirconia – Technology



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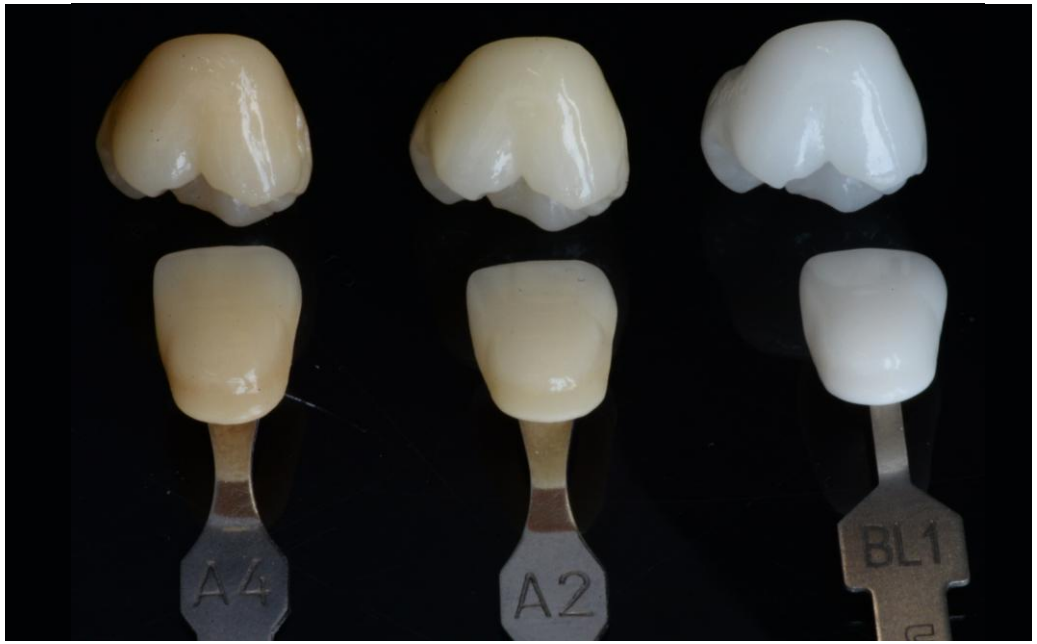
IPS e.max Zirconia – Shade Development

Next generation shading technology



- 4 BL and 16 AD shades
- Clinical try-ins
- Customer feedback

- Decision for esthetics
- 306 development iteration
- > 1300 restorations for evaluation

IPS e.max Zirconia Color & Translucency Concept

Translucency gradient with GTx
2 different material types for dentin (4Y-TZP) and incisal (5Y-TZP) and additional gradient due to color concentration

Color gradient
6 different coloring components in IVAG GTx
NEW Zirconia generation.
40 individual recipes for 20 A-D and BL shades

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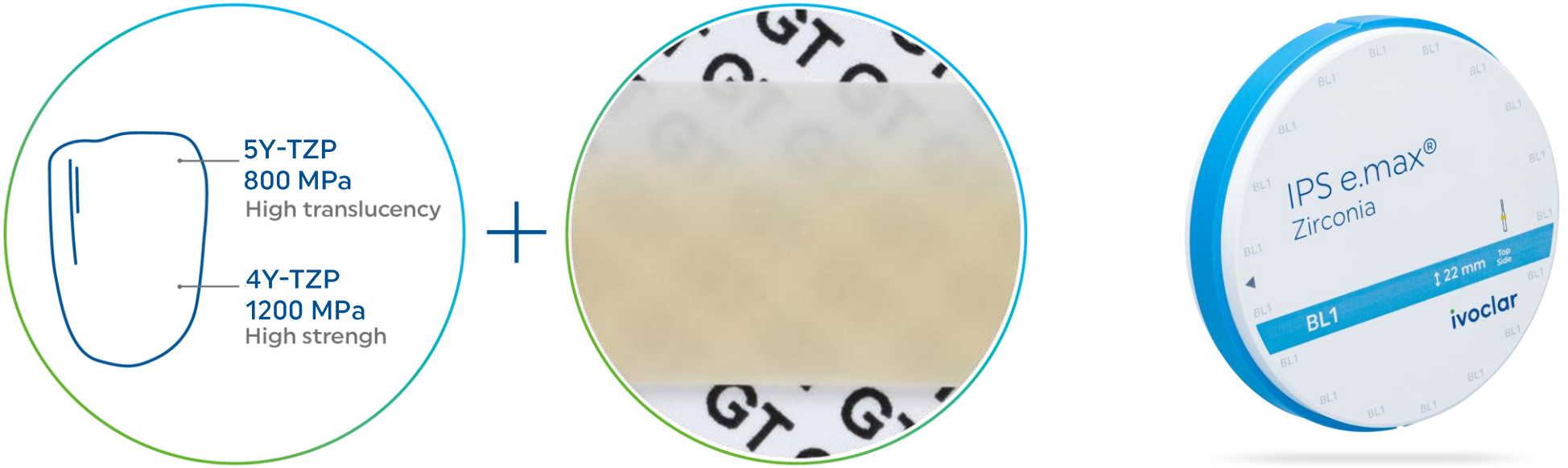
GTx Technology – IPS e.max Zirconia

The **IPS e.max Zirconia** is redefining zirconium oxide.

The material has a unique composition of raw materials.

Containing extremely strong and highly translucent zirconia, featuring the innovative **GTx Gradient Technology**.



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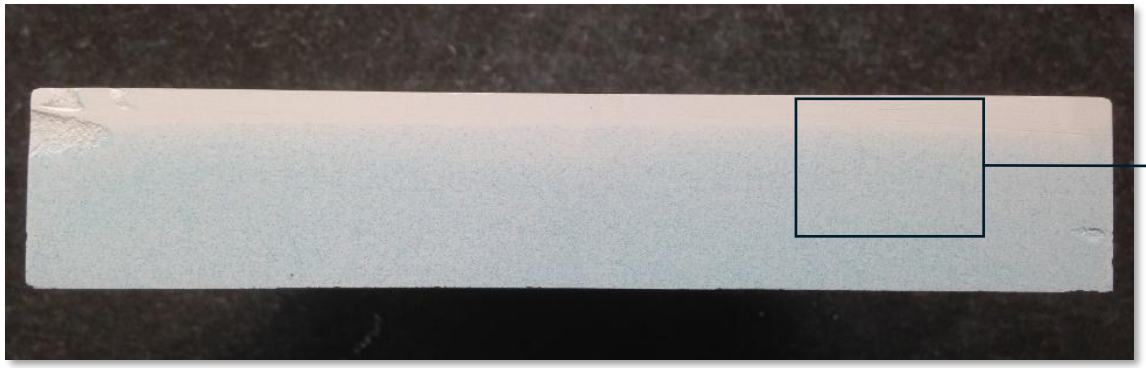
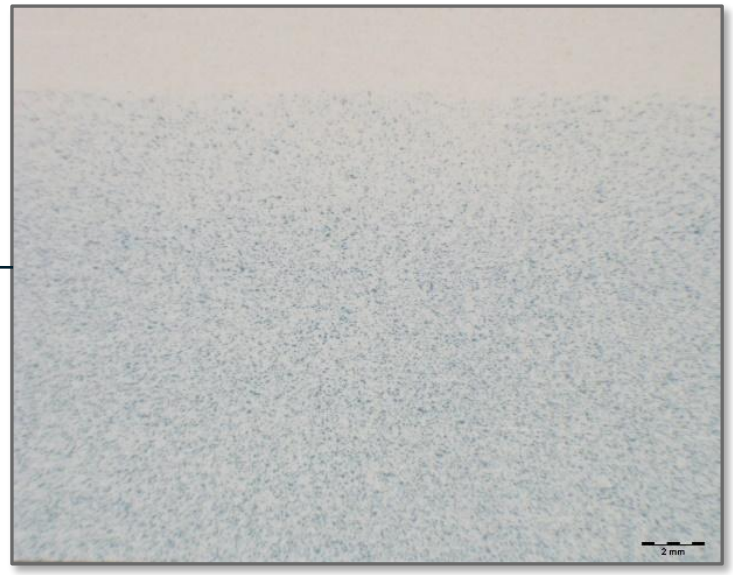
GTx Gradient Technology

Benefits of the unique filling technology



development sample

Ξ NO LAYERS Ξ



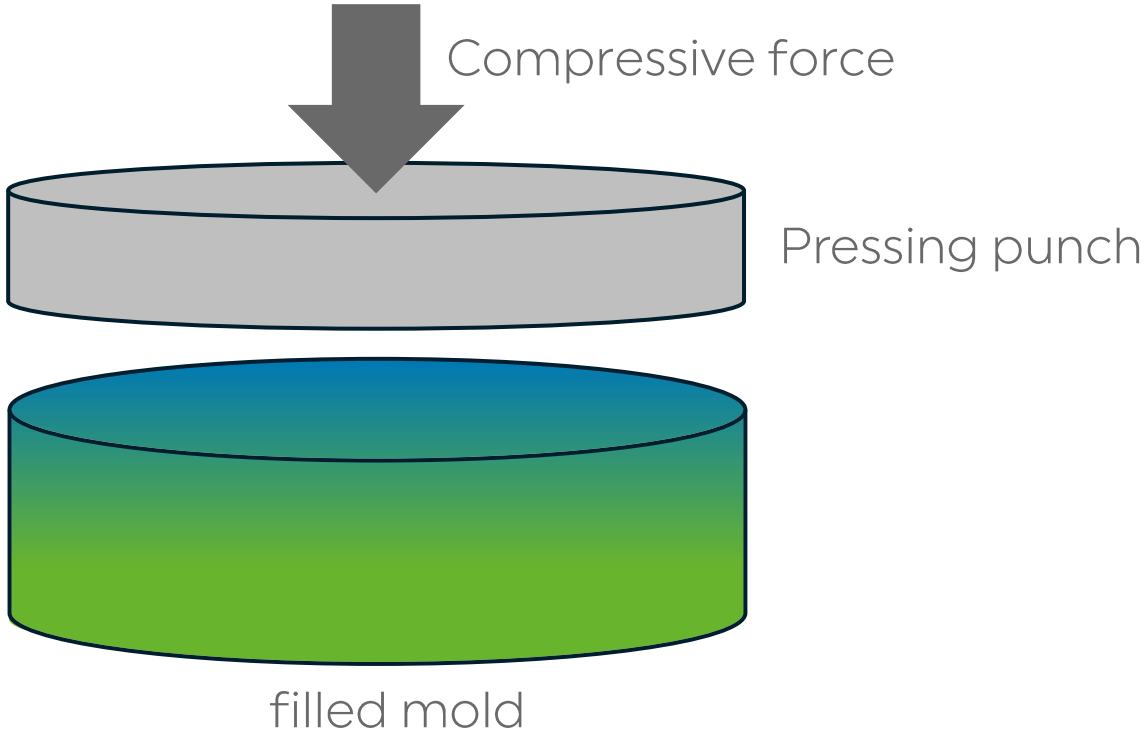
zoom

Stepless color- and translucency gradient

GTx - Pressing Technology

High-quality **pressing** technology

Step 1: uniaxial pre-pressing process



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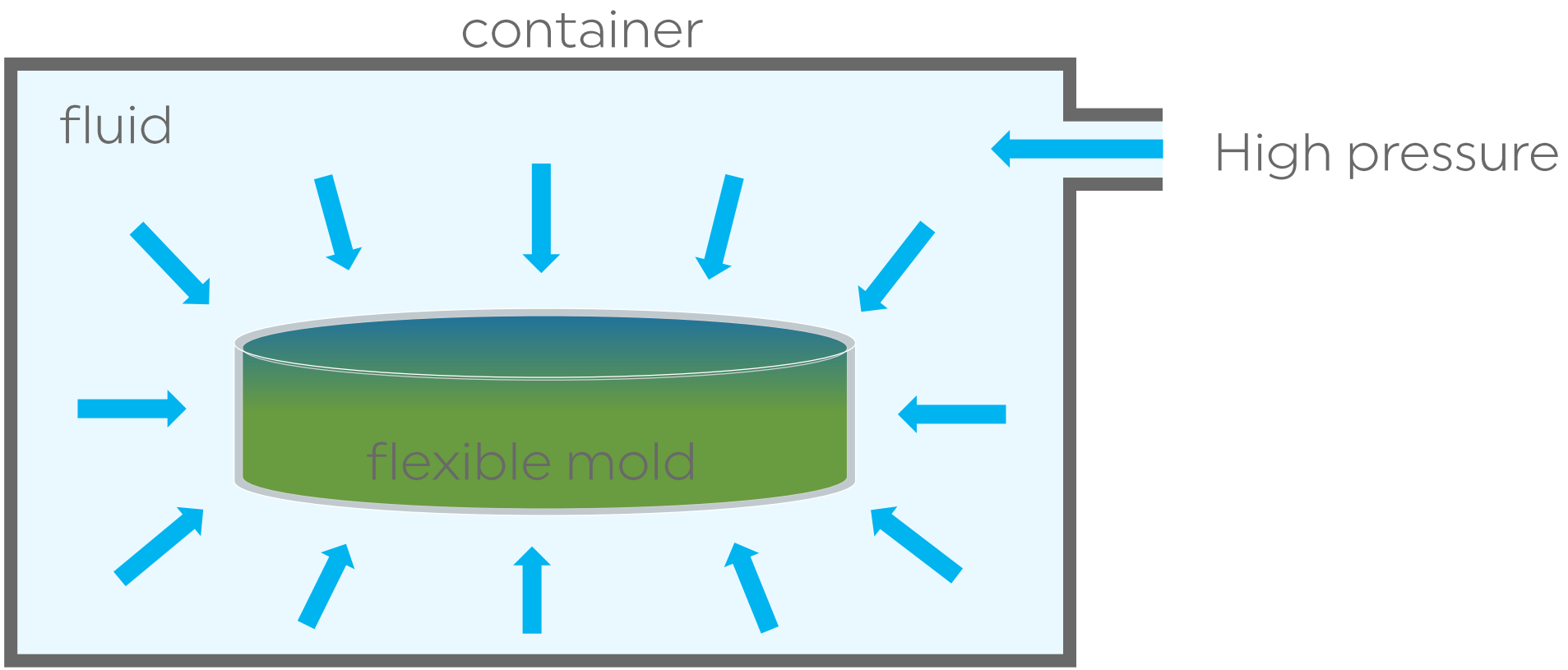
GTx - Pressing Technology

High-quality **pressing** technology

Step 2: cold isostatic pressing (CIP)



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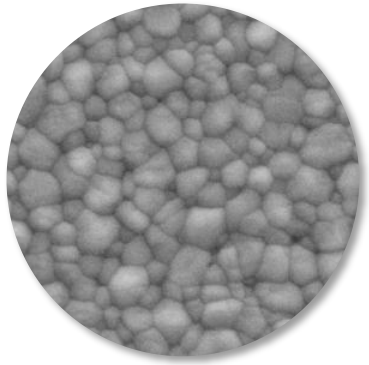
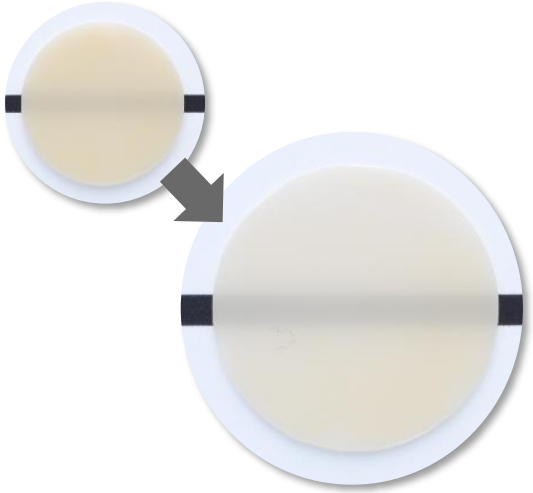
GTx - Benefits of the Pressing Technology

Better homogeneity



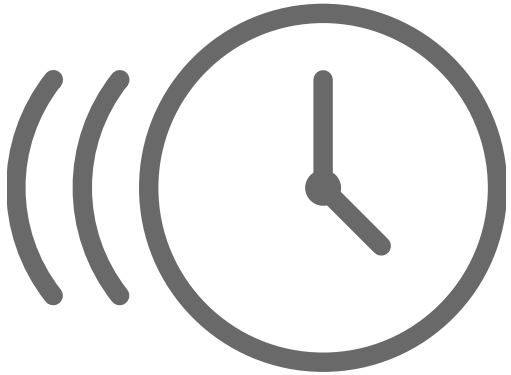
- less defects
- highly compressed structure
- no density gradients (very good fit accuracy)

Higher translucency



- higher translucency
- important for zirconia with less Y_2O_3.

Faster sintering cycle



- faster sintering cycle
- single crowns up to 3-unit bridges < 1 h

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IDC – Intelligent Disc Concept

Standard positioning = ~1 mm from top

- Same nesting routine
- Same color
- Same outcome and quality

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Pre-sintering / Machinabillity

- Soft structure for easy milling, white hardness ~500 MPa
- IPS e.max Zirconia is edge stable even at the thickness of 0.2 mm of the specimen

Current Zirconia
Thickness 0.2mm

Competitor zirconia
Thickness 0.2mm

IPS e.max Zirconia
Thickness 0.2mm

ISO18675:2022 Machinabillity test norm

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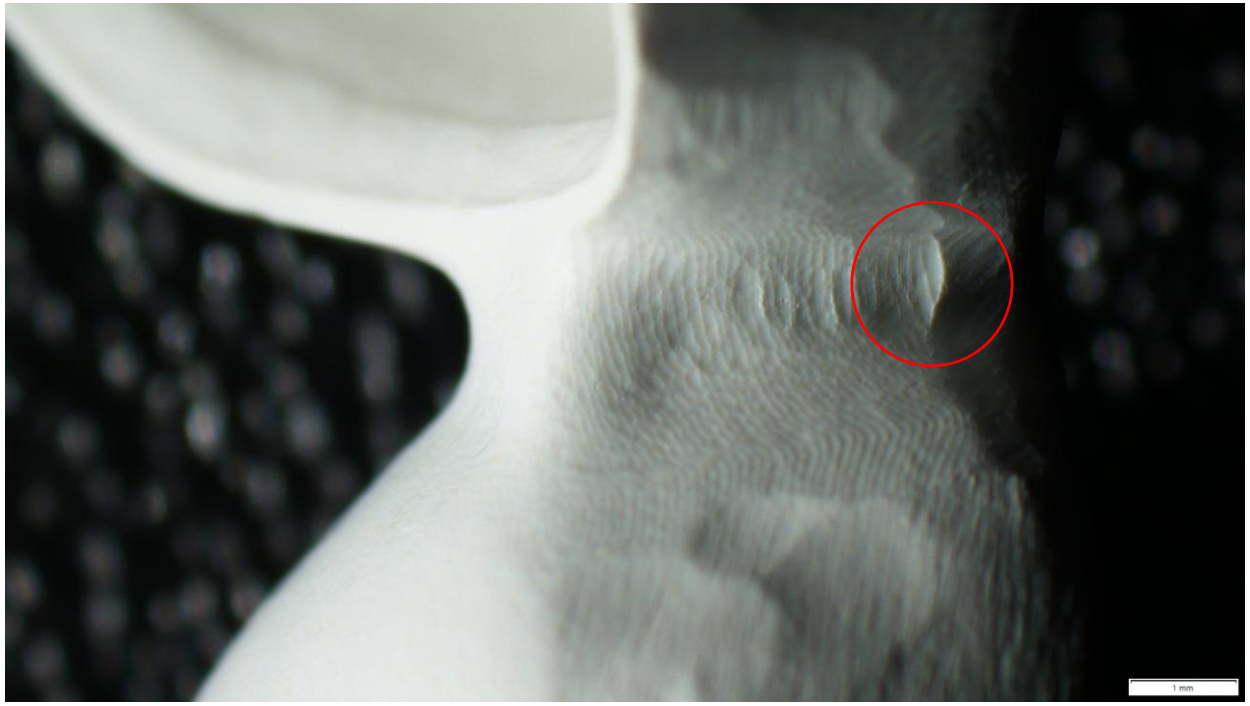
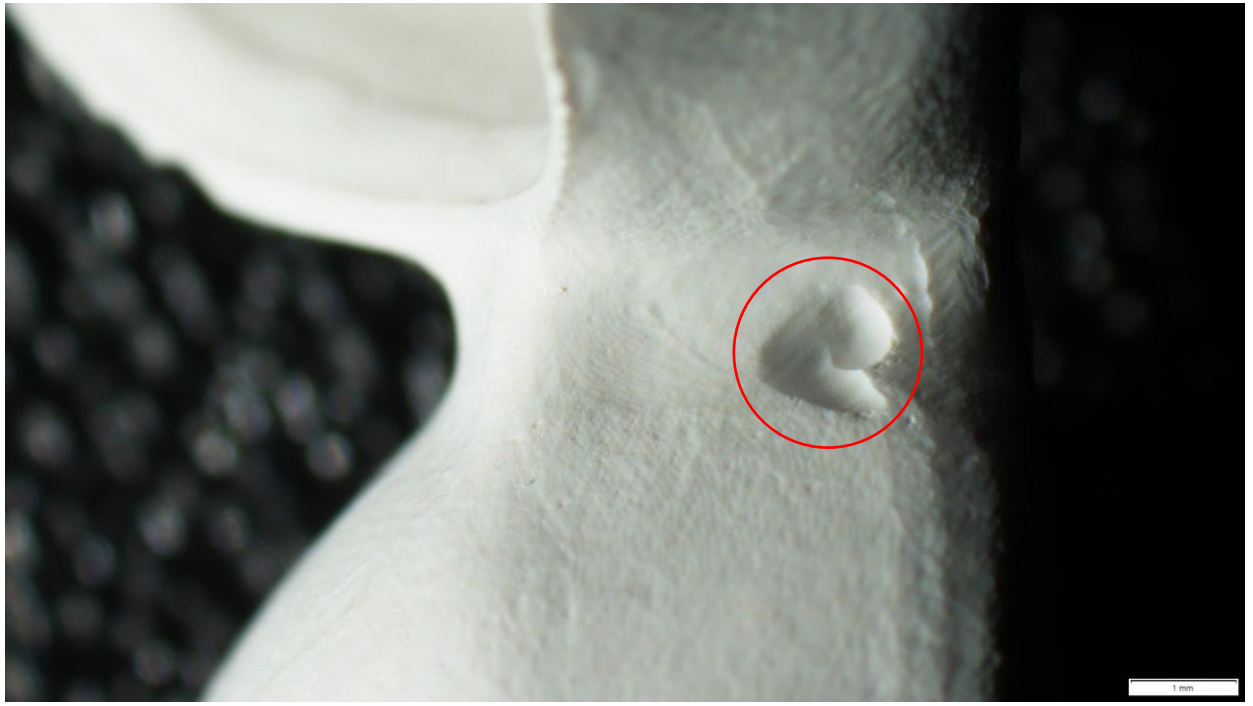
Factors Affecting Longevity

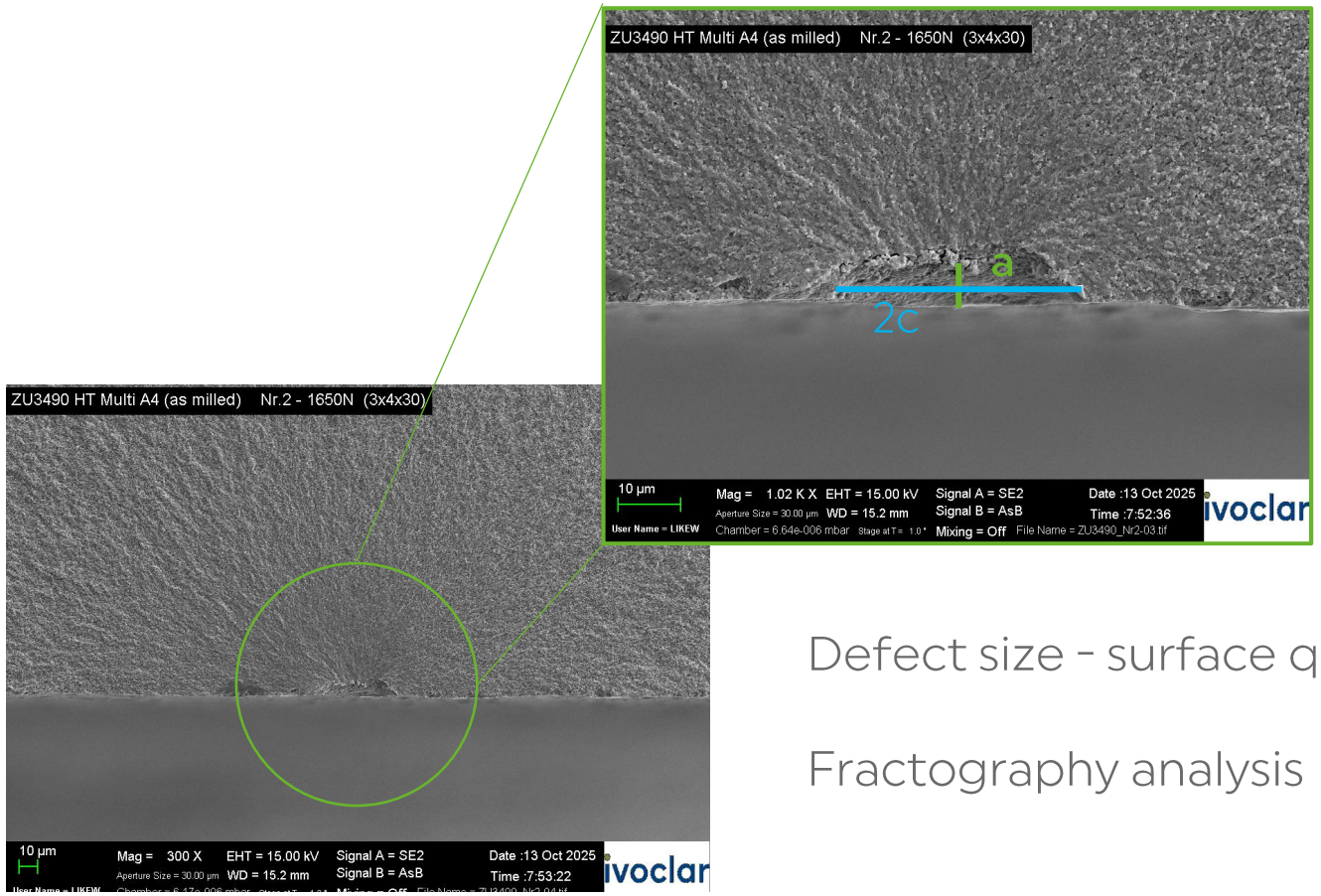




- TO BE AVOIDED: sharp curves (left), milling surface defects as holes (right)
- CHOOSE: right milling strategy and tools
- CHECK: restorations for visible defects

Four Point Bending Test

Influence of the milling on the surface quality and defects in sintered state?

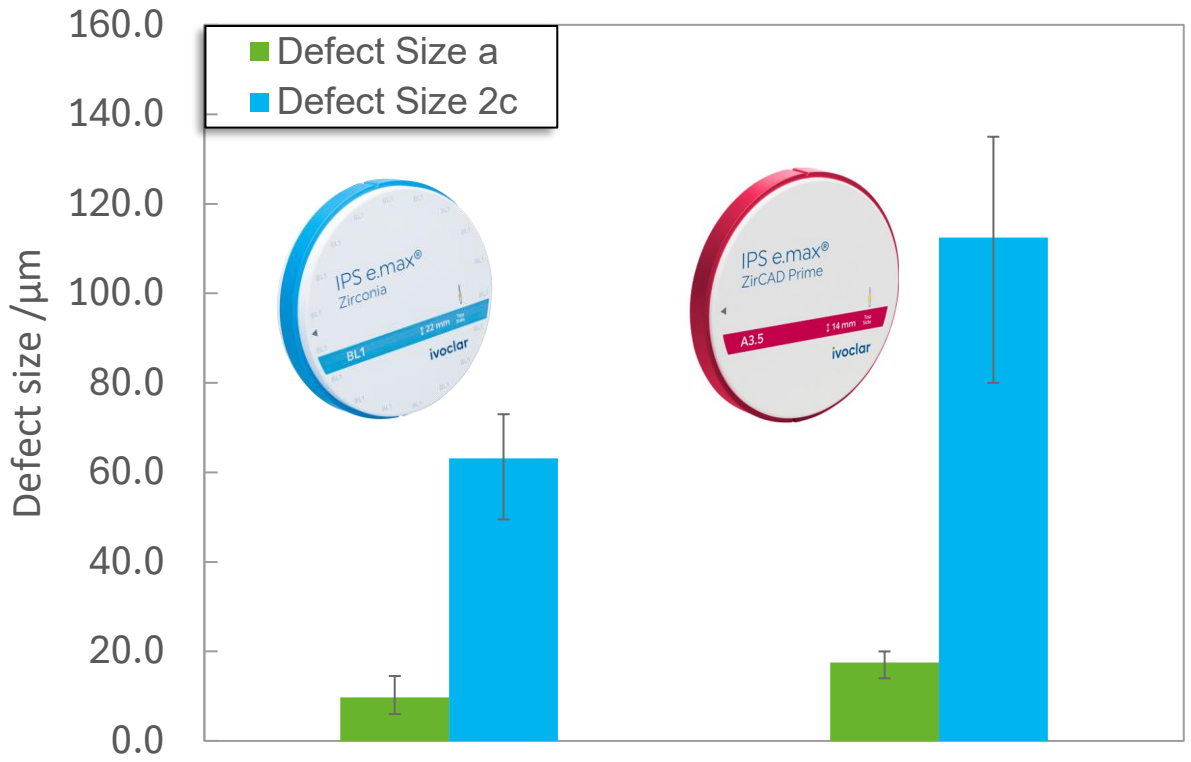


Defect size - surface quality

Fractography analysis

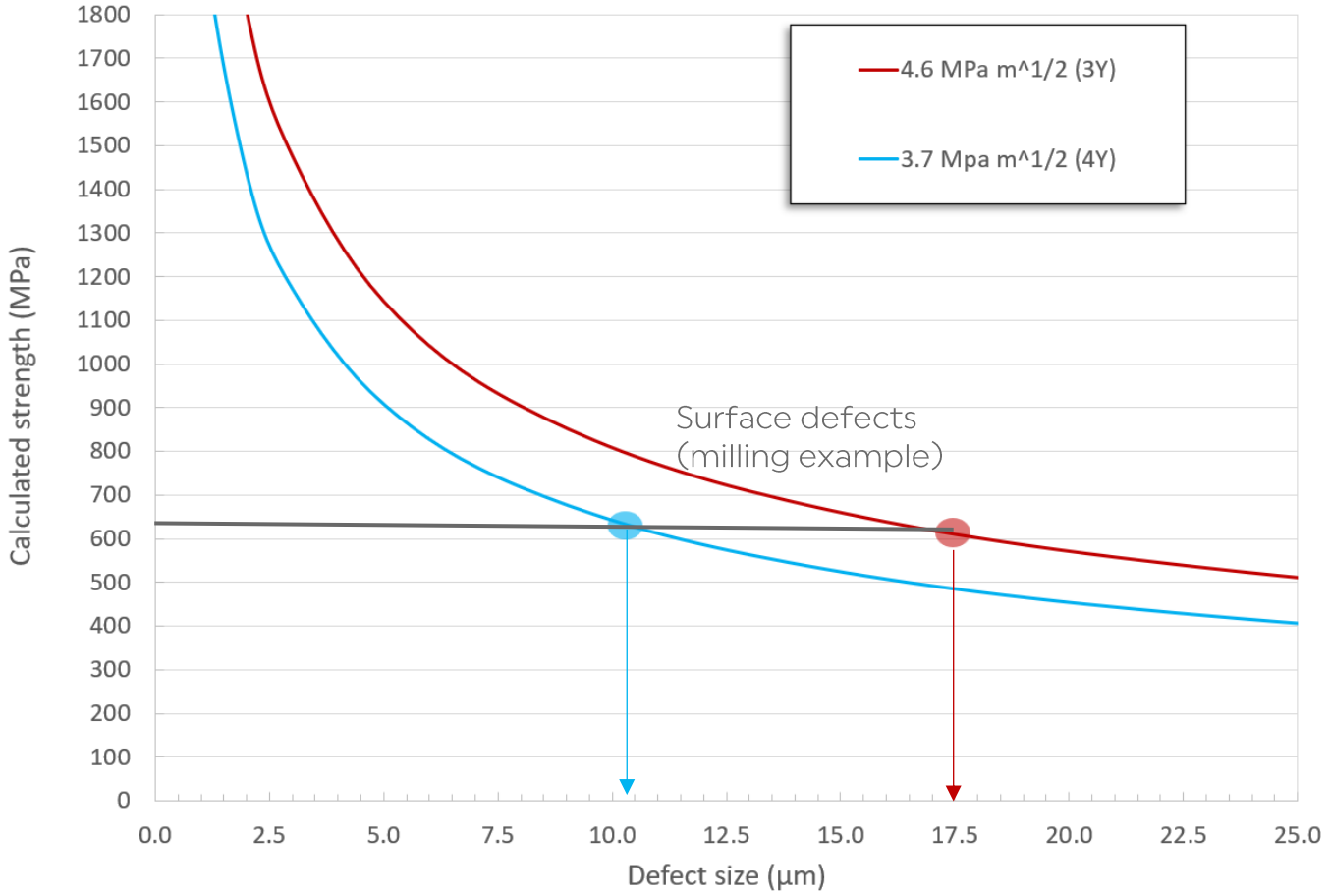
Defect size

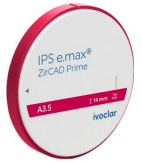
Surface defect size smaller for IPS e.max Zirconia compared to IPS e.max ZirCAD Prime



Material Sensitivity - Defect Size

Due to nature of material grade (4Y) IPS e.max Zirconia is more sensitive with increase of the defect size in comparison with (3Y) Prime.



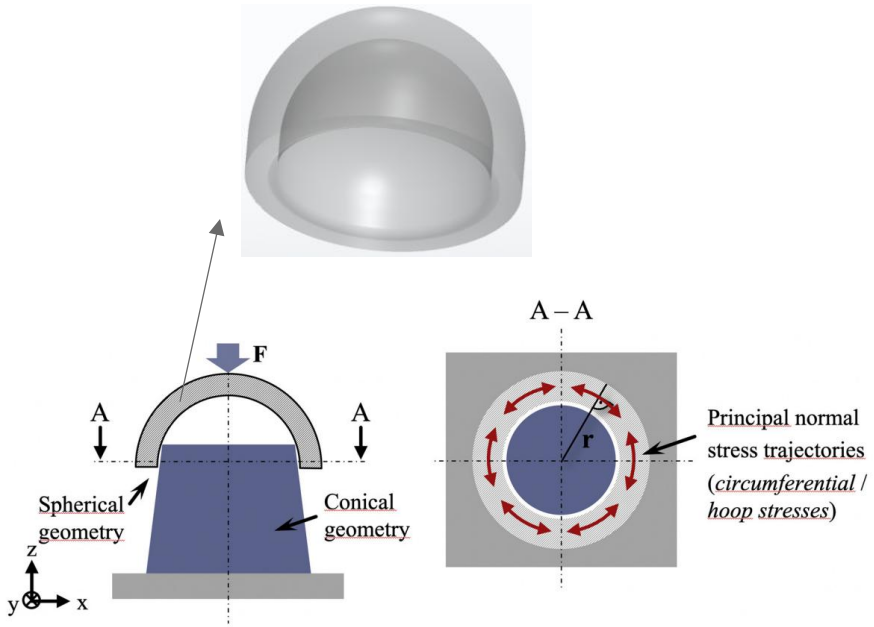


Higher fracture toughness!

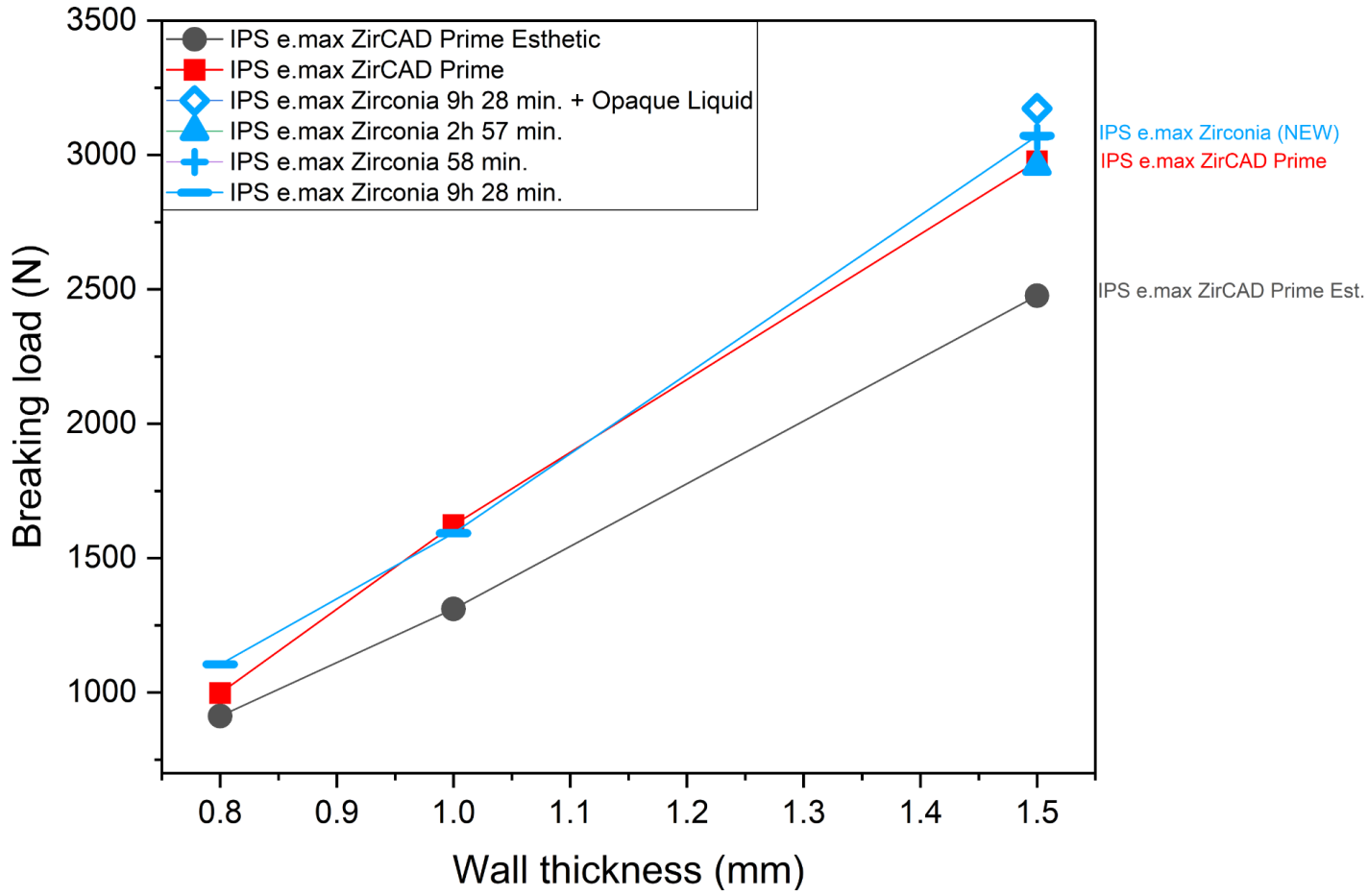
Hoop Strength Tests

Measuring the material's resistance to fracture under circumferential tensile stress

Dome-shaped specimens (crown-like geometry)



R. Belli et al. Journal of the European Ceramic Society, 2020.



IPS e.max Zirconia Sintering

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Sintering kinetics (IPS e.max Zirconia)

With today's knowledge and new generation of materials / shading technology we have very good adjustment of sintering kinetics.

Improved robustness – universal product for standard and speed sintering, fitting accuracy.

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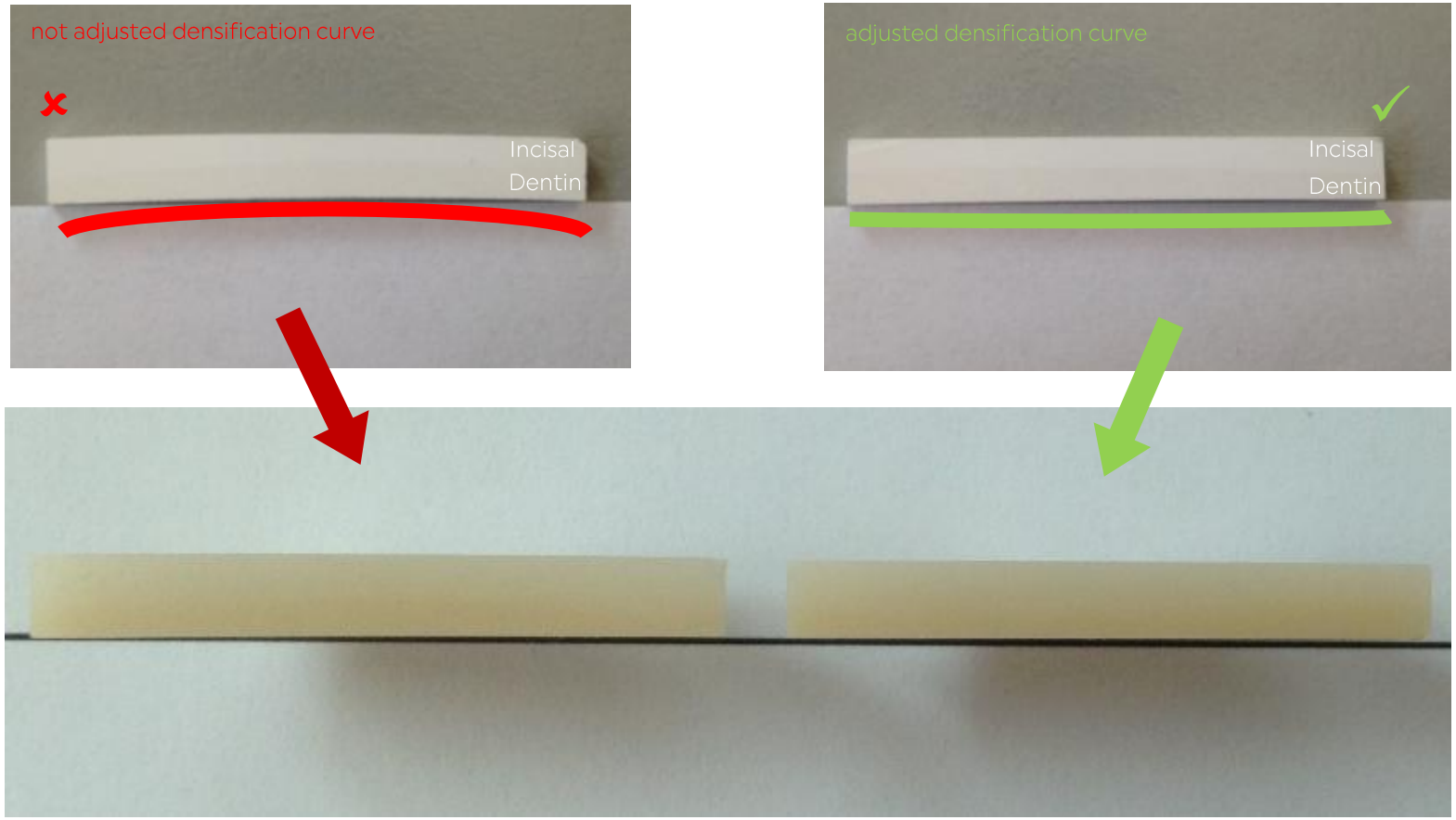
Adjusted sintering kinetics

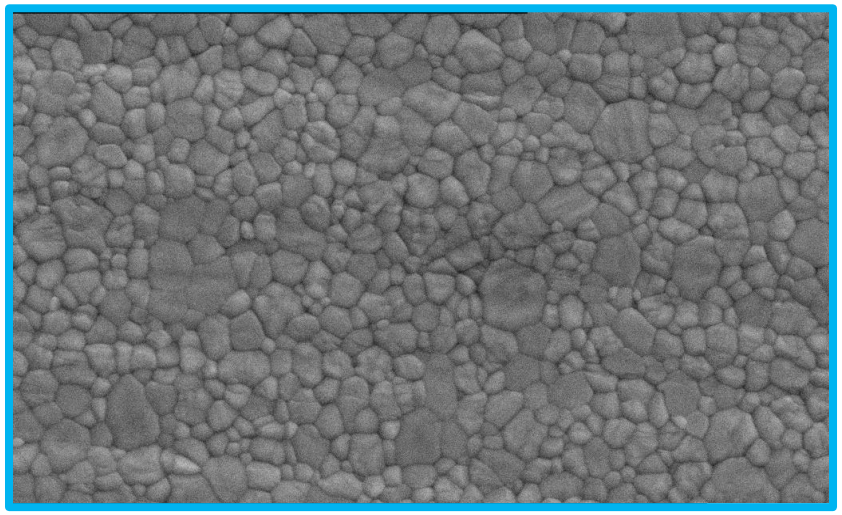
Distortion



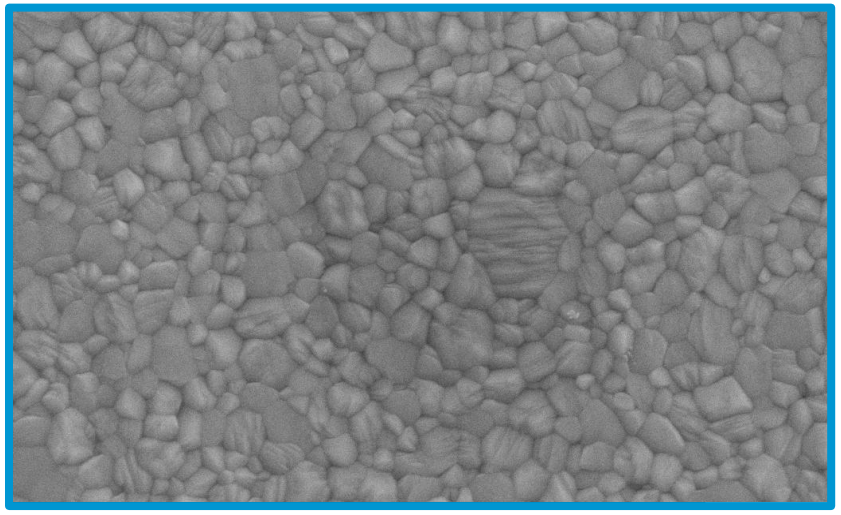
The combination of different Zirconia powders with varying Yttria-content and color gradient leads to distortion in the **pre-sintered** and/or dense **sintered** state: Adjustments of sintering kinetics are mandatory.

Standard **vs** Speed sintering (Worst Case)

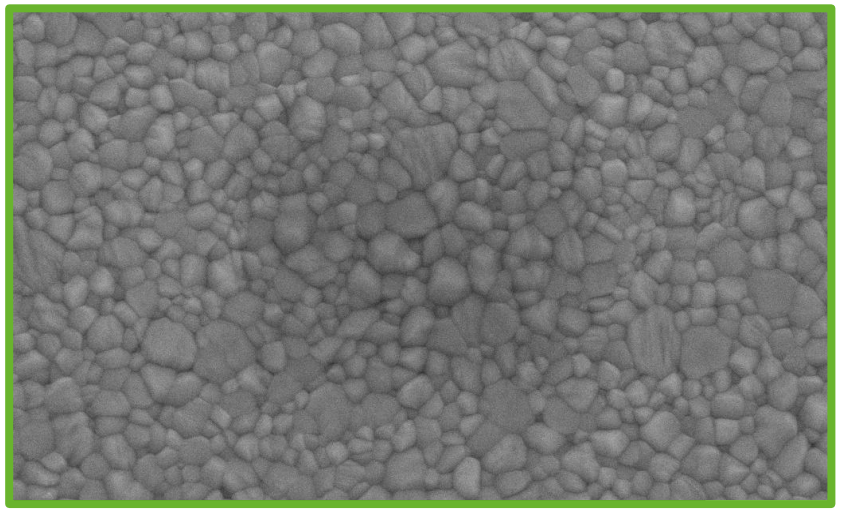
Shade A4
Standard 9h 28 min.



Shade A4 infil. Liquid B4
Standard 9h 28 min.



Shade A4
Speed 58 min.



Mean grain size (µm)		
0.510 ± 0.078	0.480 ± 0.070	0.450 ± 0.080
Biaxial flexural strength (MPa)		
~1200	~1200	~1200
Fracture toughness (MPa √m)		
~3.7	~3.7	~3.7

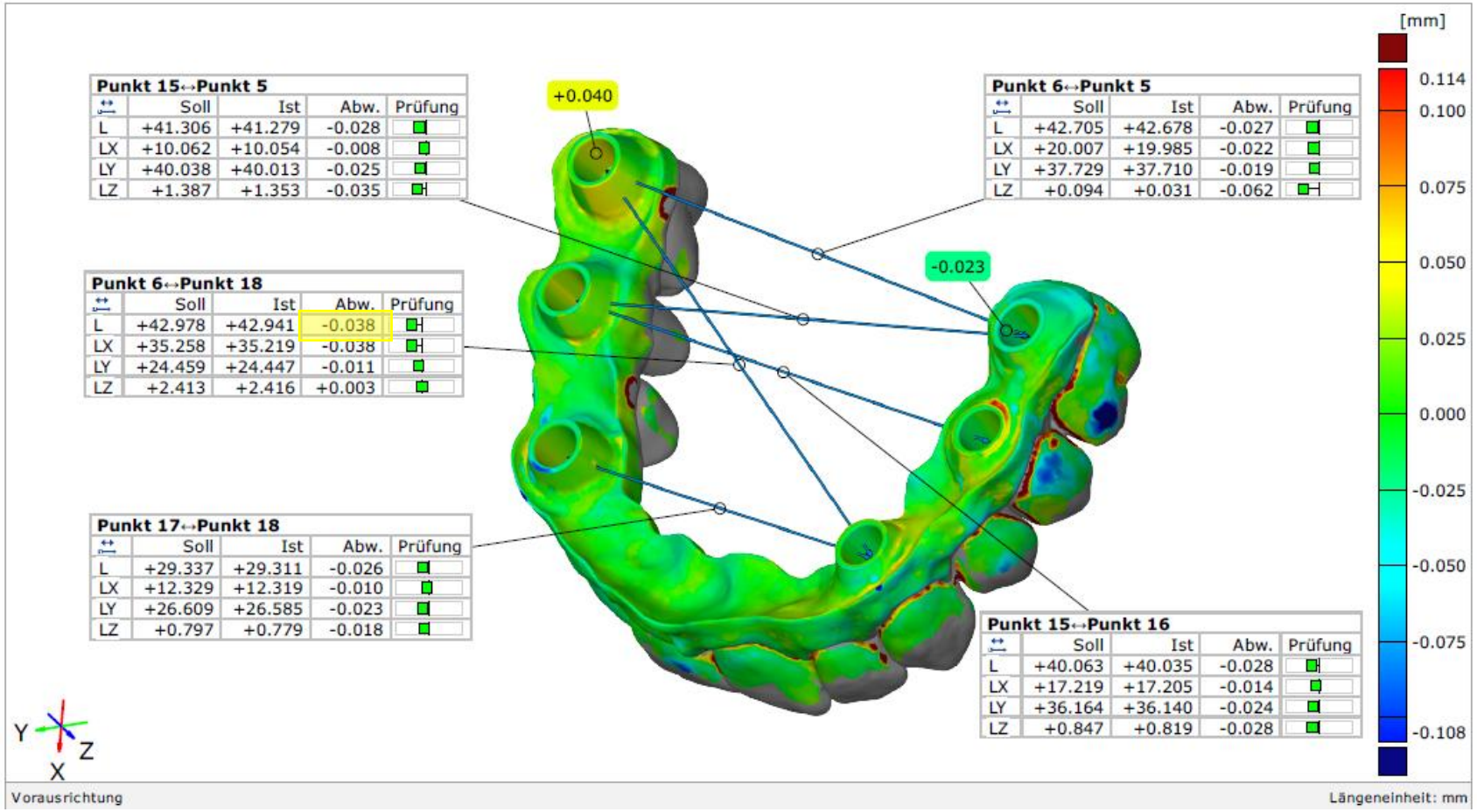
Fitting accuracy (GOM)

- Clinical acceptance criteria ~ 80 µm
- Ivoclar acceptance criteria < 50 µm

IPS e.max Zirconia ✓

STANDARD SINTERING (9h 28 min.)

Minimal deviation = 38 µm



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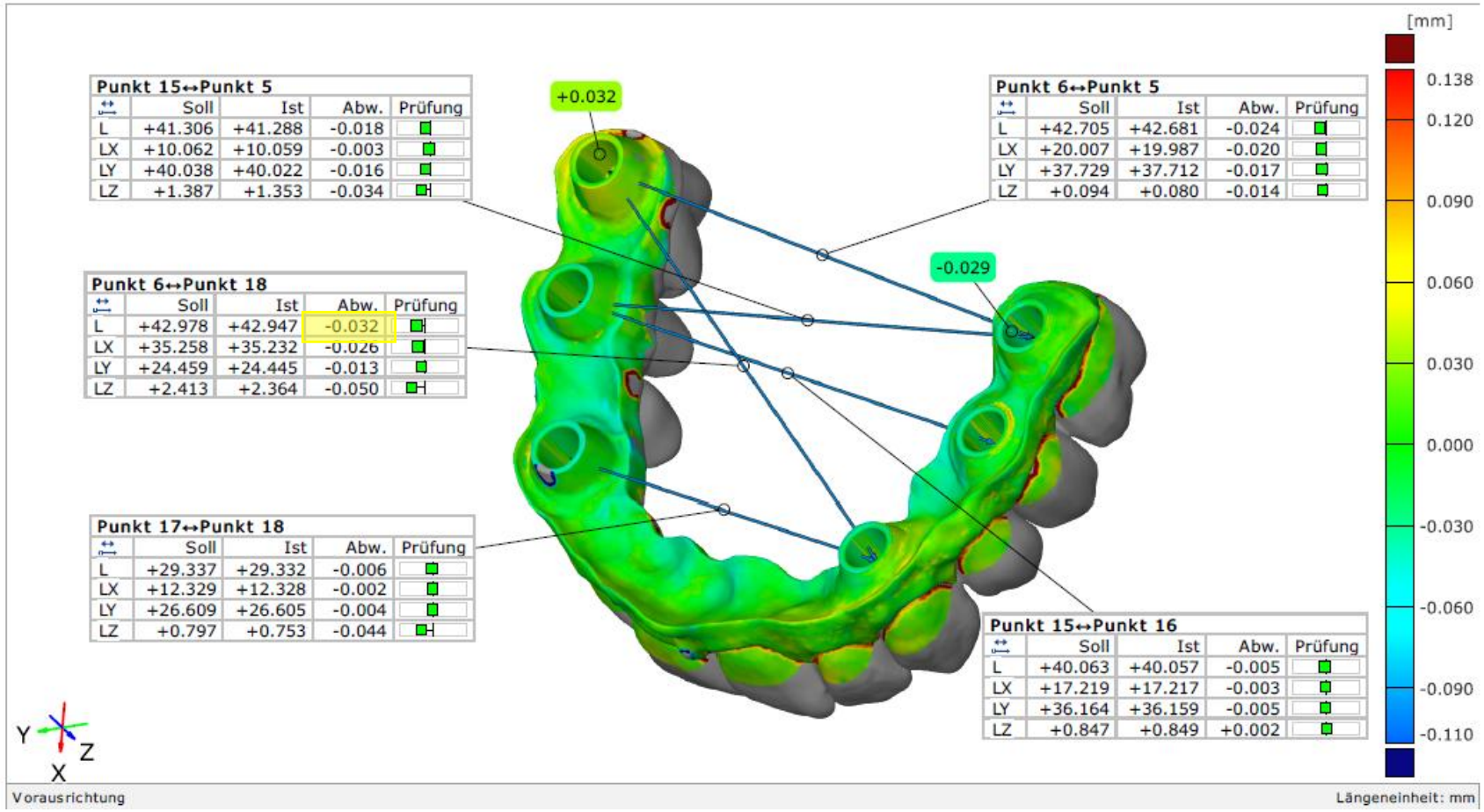
Fitting accuracy (GOM)

- Clinical acceptance criteria ~ 80 µm
- Ivoclar acceptance criteria < 50 µm

IPS e.max Zirconia ✓

SPEED SINTERING (2h 57 min.)

Minimal deviation = 32 µm



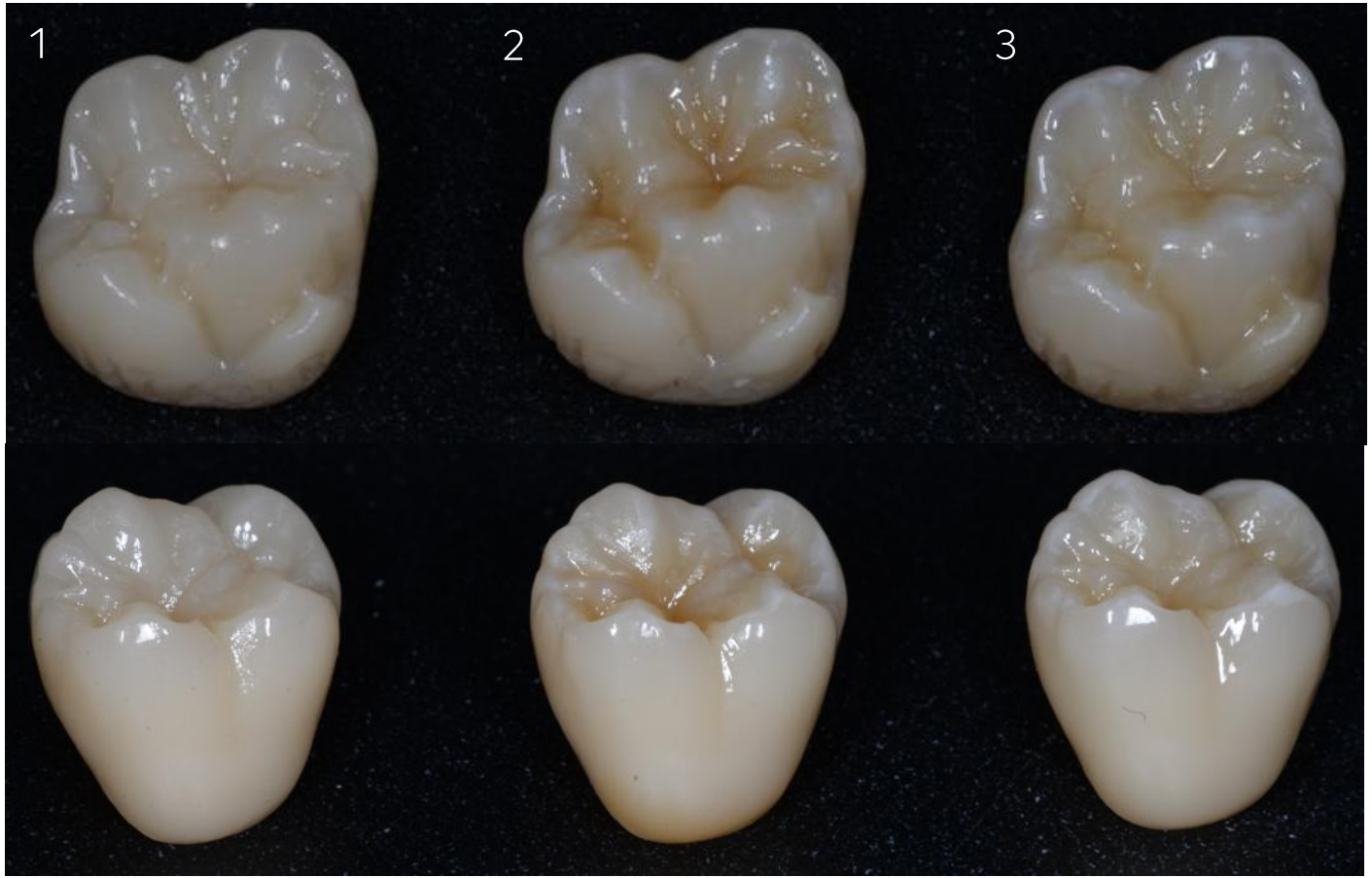
IPS e.max Zirconia Liquids / Inflitration

Indicators on Zirconia

- For dipping infiltration and brush infiltration
- Coloring / Effect liquids with indicator included for very good visualization and controlled application of the different liquid types

Effect Liquids
Opaque/White, Grey, Blue, Violet, Orange, Brown

IPS e.max Zirconia and Characterization Infiltration



1. **IPS e.max Zirconia A3 - reference**

2. **(Standard sintering / glaze)**
   - fissure
   - oclusal liquid A3
   - cusp tips, white effect
   - incisal blue effect
   - cervical margin, orange effect

3. **(Speed sintering / glaze)**
   - oclusal liquid A3
   - cusp tips, white effect
   - incisal blue and grey effect
   - cervical margin, liquid A3

IPS e.max Zirconia Opaquing Liquid

- Good white / opaquing effect available for different applications
- Maintains the color effect of the substrate
- No change in physical properties in comparison with reference Zirconia, in-vitro studies or fitting accuracy
- Cover dark abutments or metal posts
- Patent application pending: EP4091577 A1, published in CN, EP, JP, KR, US

User feedback:
Very good result visually

Example: core build-up on devitalised tooth with white acrylic build-up; Prime Est. A2 with Effect liquid Zirconia 2.0 opaque

IPS e.max Zirconia Preclinical Testing

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In-Vitro Meets In-Silico: Verifying Material Quality

- **In-vitro** testing mimics oral conditions but cannot capture full in-vivo complexity
- **In-silico** simulations extend beyond experimental limitations
- **Combined** methods improve predictions of in-vivo performance

In-vitro

In-silico

Combined

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Deep-Dive Testing of IPS e.max Zirconia

Our preclinical testing approach simulates strict worst-case conditions to ensure safety

IVOCLAR

e.g. bridges

F = 550N ~ 56 kg for 2,000,000 cycles

Clinically relevant

COMPETITOR

e.g. bridges

F = 50N ~ 6 kg for 1,200,000 cycles

NOT Clinically relevant

Does not replicate fatigue mechanism

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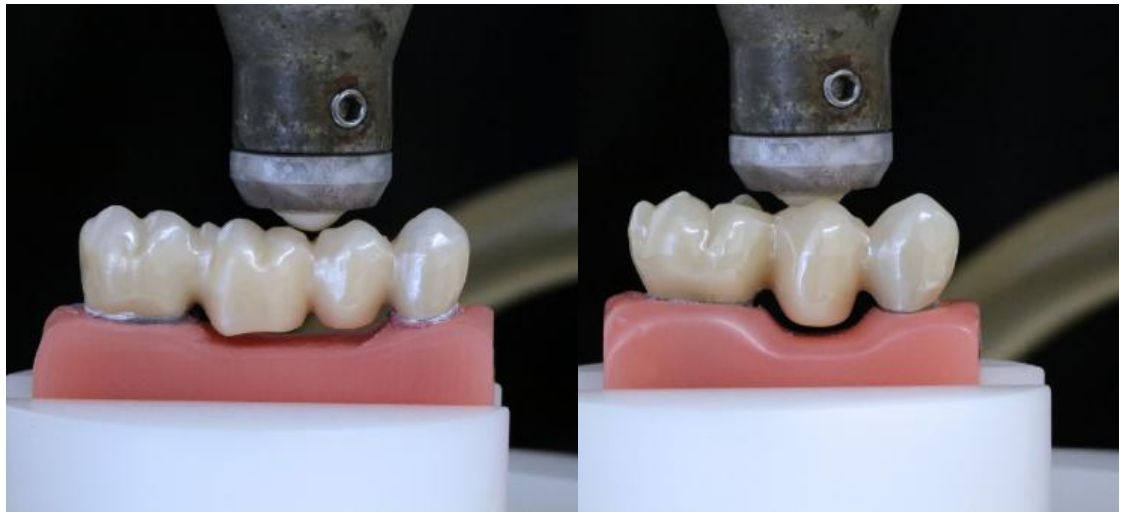
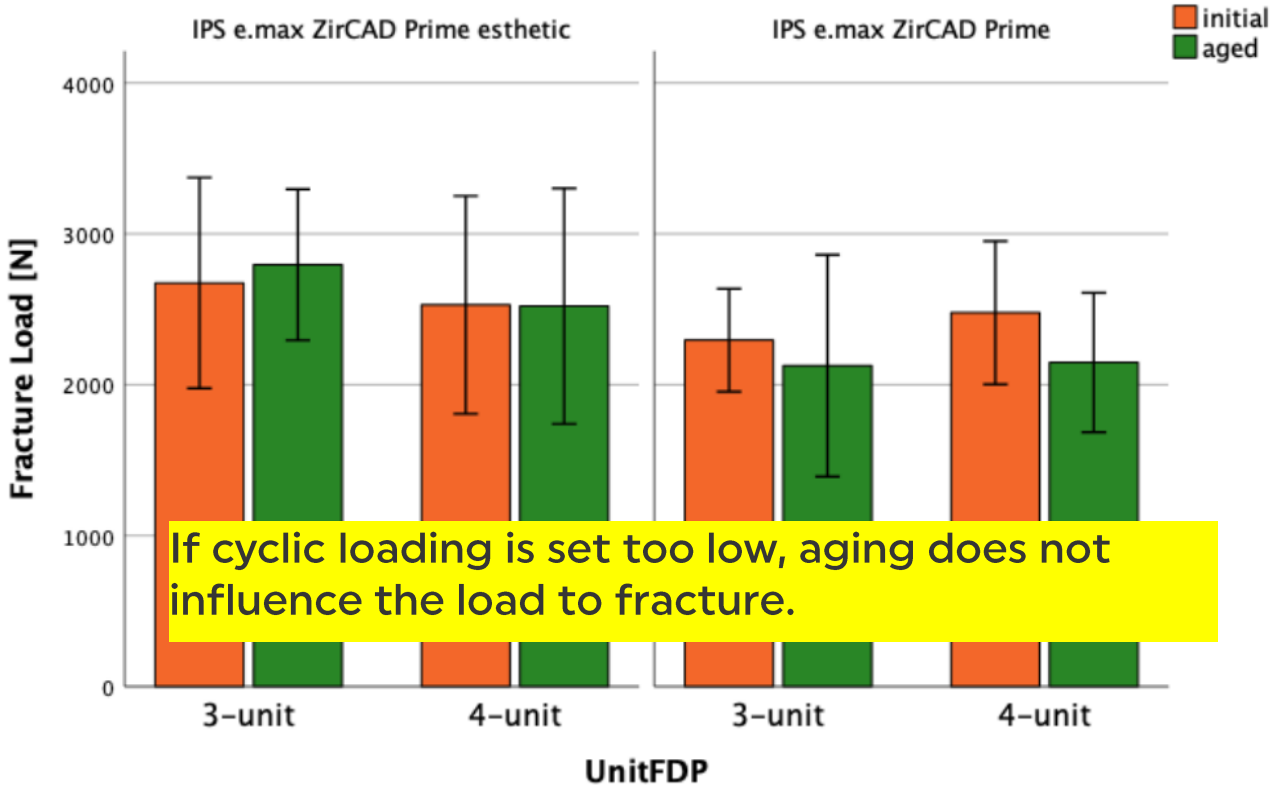
Why do we test with chewing forces far above the average human bite force?

Thermal-cycle test

- 2,400,000 mechanical cycles (50 N, 1.5 Hz)
- Thermo-cycles: 12000 x (5/55°C, dwell time of 60 s)



Load to Fracture



If cyclic loading is set too low, aging does not influence the load to fracture.

- Clinical studies indicate the most common FPD failures are fatigue-related, not impact-related.
- Testing should replicate clinically relevant fatigue mechanisms.
- 550 N is based on Ivoclar's long-term clinical experience across numerous dental materials.

*: The investigations were conducted by Prof. Dr. Bogna Stawarczyk in Department of Prosthetic Dentistry LMU Munich

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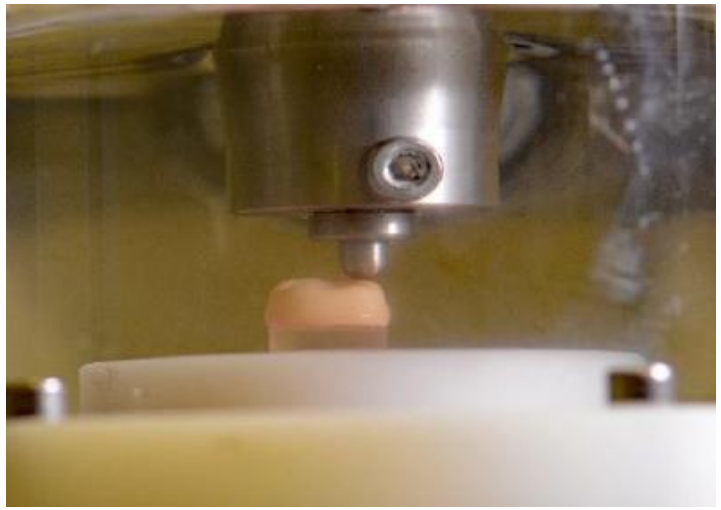
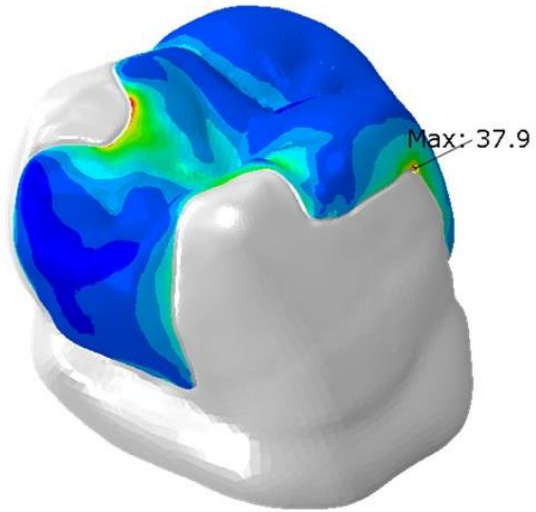
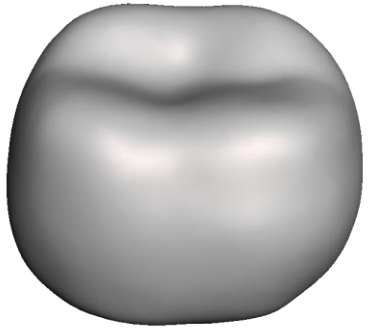
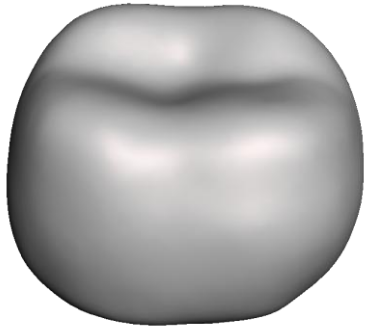
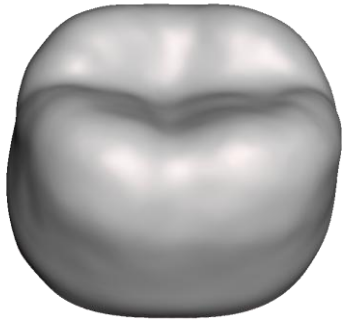
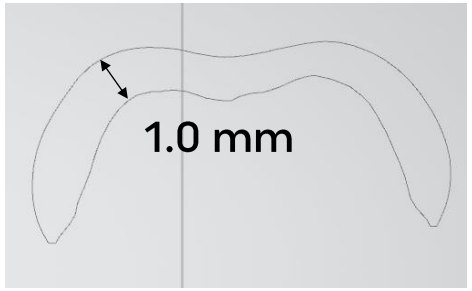
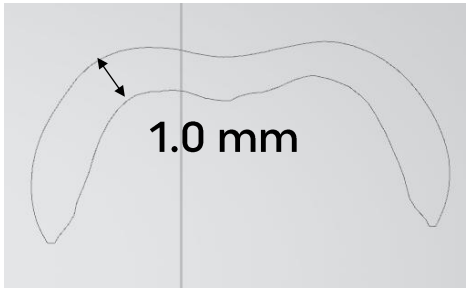
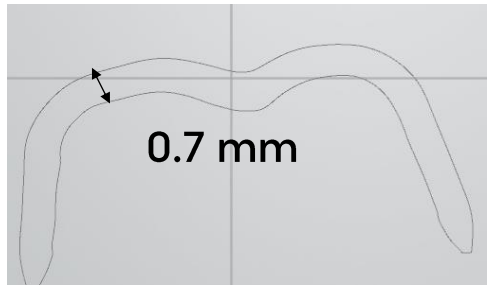
Speed Sintering You Can Rely On

- Speed sintering was treated as the worst-case condition; all restorations were tested using the speed program
- Multiple restoration types were additionally tested under both speed and standard sintering
- No performance differences were observed between the two sintering programs





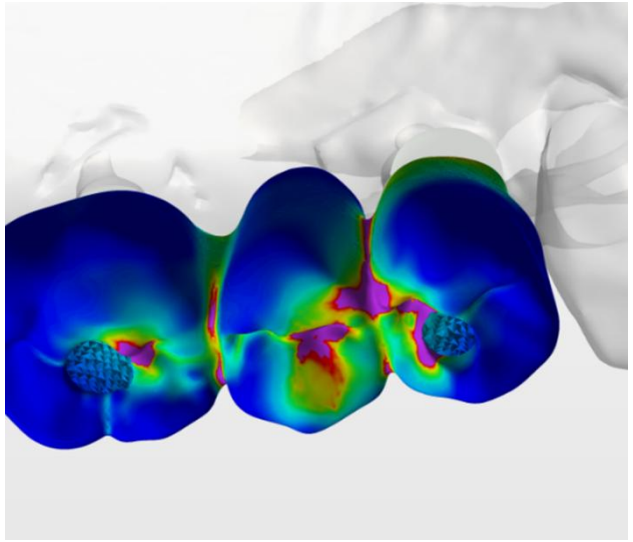
Minimum Design Dimensions

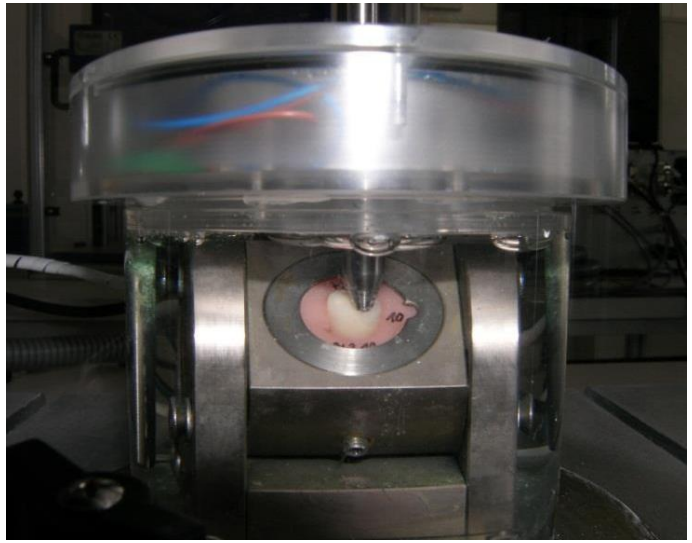
IPS e.max ZirCAD Prime	IPS e.max ZirCAD Prime Esthetic	IPS e.max Zirconia
		
Flexural strength 5Y – 650 MPa Fracture toughness 5Y – 2.7 MPa √m		Flexural strength 5Y – **800 MPa** Fracture toughness 5Y – 2.7 MPa √m
		

- In oclusal area the thickness has been reduced to 0.7 mm for IPS e.max Zirconia due to increase of flexural strength in 5Y material (new generation of zirconia used).

Full Validation Summary: From Testing to Confidence

- Over 50,000 hours of testing completed
- All indications tested multiple times to build high confidence
- Every IfU-specified dimension thoroughly tested and verified
- Goal is longevity, not competing to minimize design parameters
- As far as tested, no competitor material has fulfilled our strict testing criteria





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Thank you

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