The influence of glaze on the tribological properties of zirconia dental pieces obtained by subtractive and additive manufacturing

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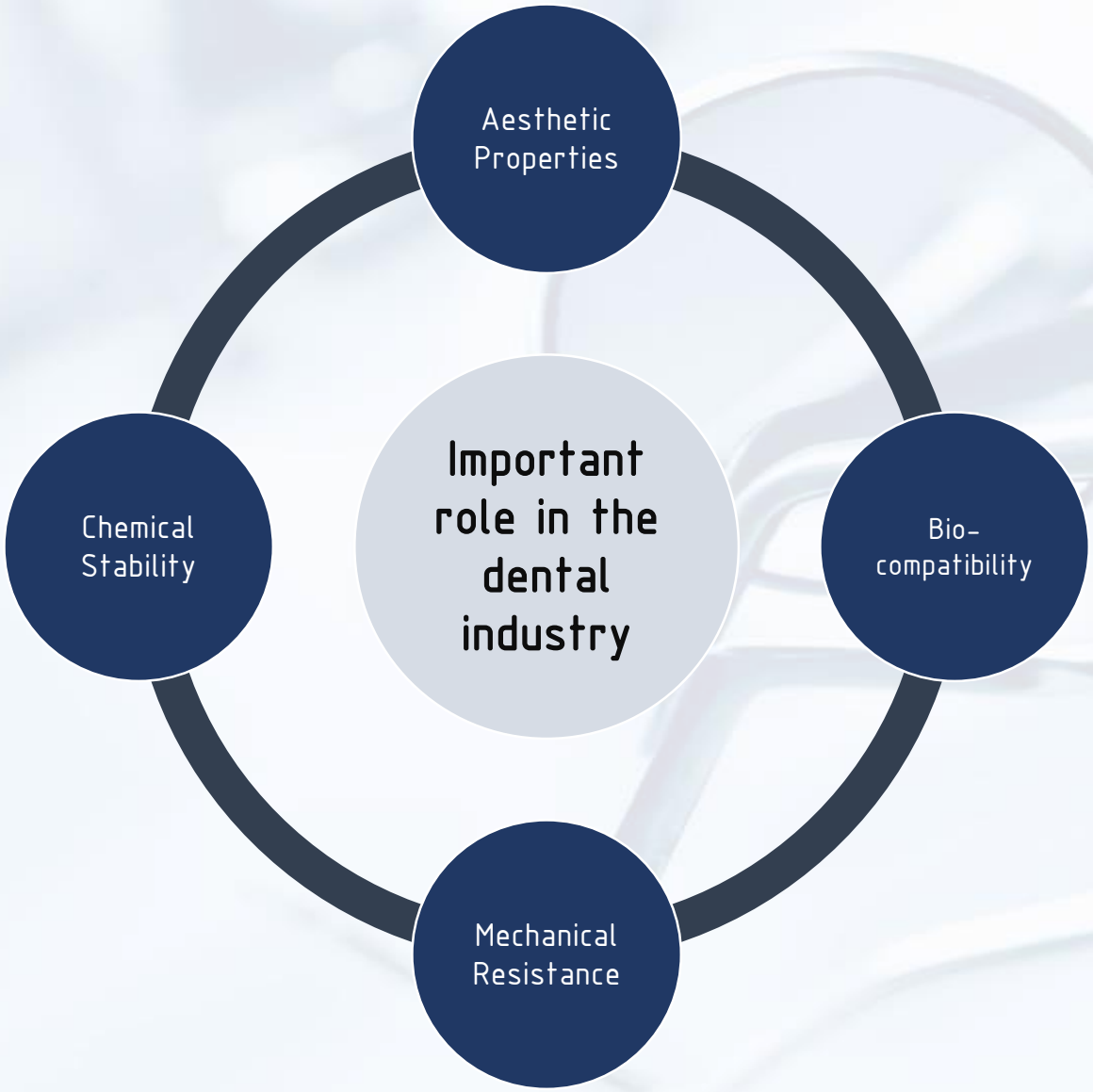
Ceramic based prosthetic materials for dental restorations



Most commonly used ceramic dental materials

- Lithium disilicate ($Li_2Si_2O_5$)
- Zirconia (ZrO_2)
- ✓Leucite ($KAlSi_2O_6$)
- Mica
- ✓Alumina (Al_2O_3)

Zirconia

Applications

- Implants
- Orthodontic brackets
- Abutments
- Copings
- Bridges
- Crowns

Zirconia Crowns

Advantages

- Biocompatible with the tissues in the oral cavity
- Exceptional mechanical properties
- Wear resistant
- Ease of machining in the pre-sintering stage through CAD/CAM

Glazing

- Ceramic glaze paste applied over the surface improves aesthetic properties

Ceramic Glaze Paste

Subtractive manufacturing (SM) Vs Additive manufacturing (AM)

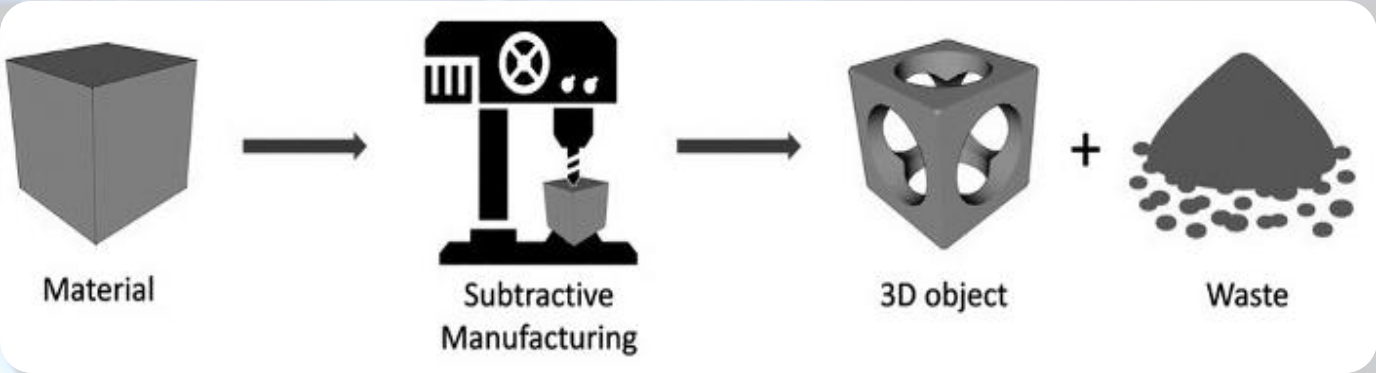
Advantages of SM

- Low post-processing
- Equipment costs are relatively reduced

Drawbacks of SM

- Wasteful process
- Accuracy of the process may be limited

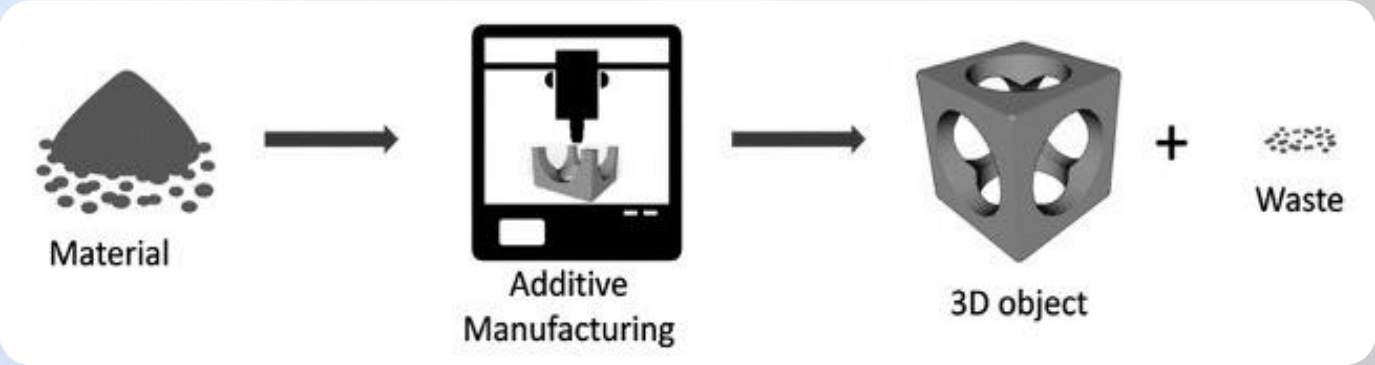
Subtractive Manufacturing



Advantages of AM over SM

- Lower waste, cost and processing time
- Less production steps
- Production of complex/personalized pieces

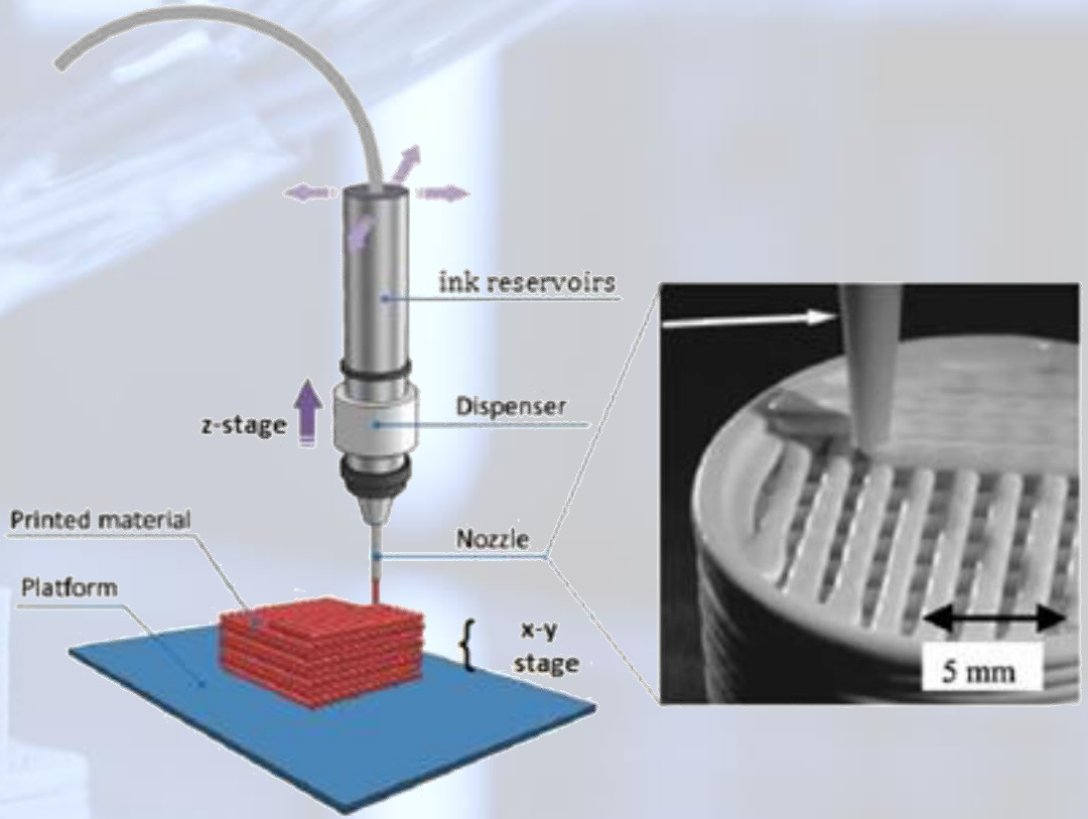
Additive Manufacturing



Objectives

1) Evaluate the potential of additive manufacturing (Robocasting) to produce reliable zirconia dental structures

2) Study the influence of glazing on the tribological performance of the obtained samples



Robocasting Technique

Characterization Techniques

Density
(Archimedes method)

Porosity
(Optical microscopy)

Hardness
(Vickers)

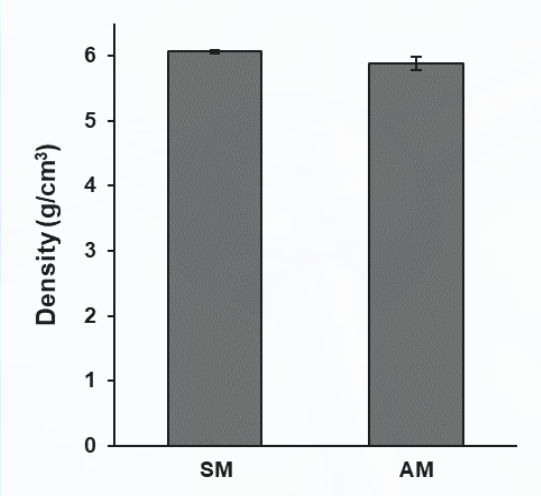
Surface Roughness
(Surface Roughness Tester)

Wear
(Chewing Simulator)

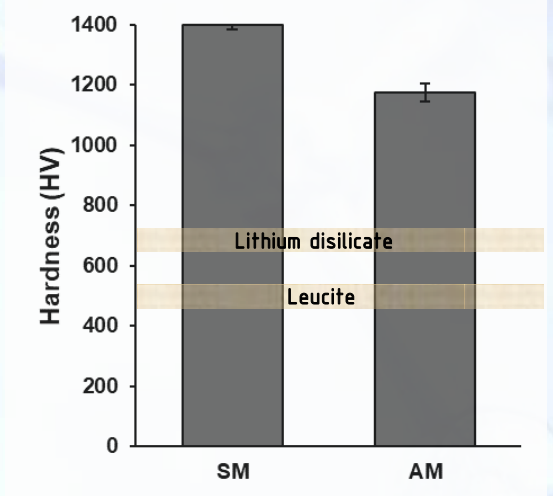
Morphology
(SEM)

Results: Zirconia Samples Characterization

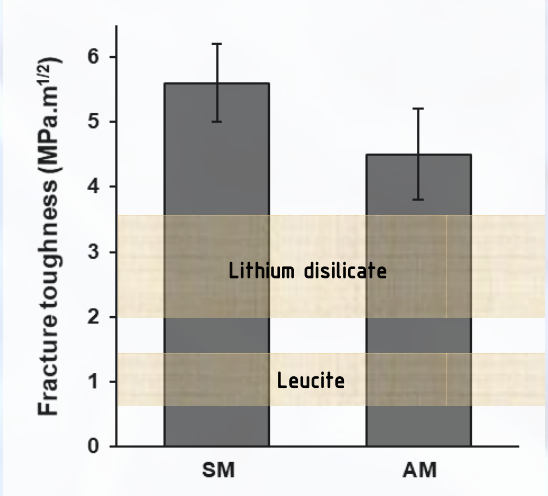
Density



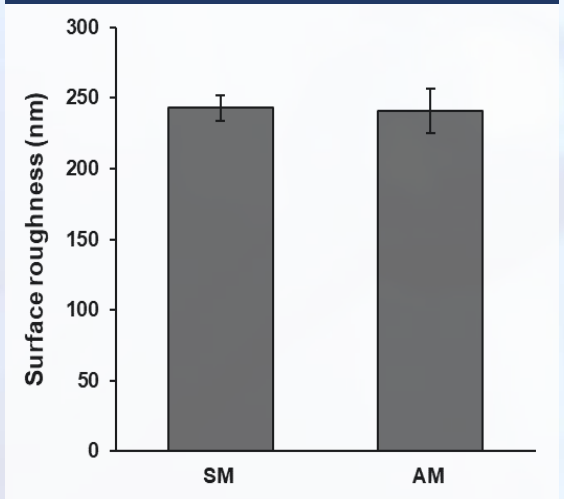
Hardness



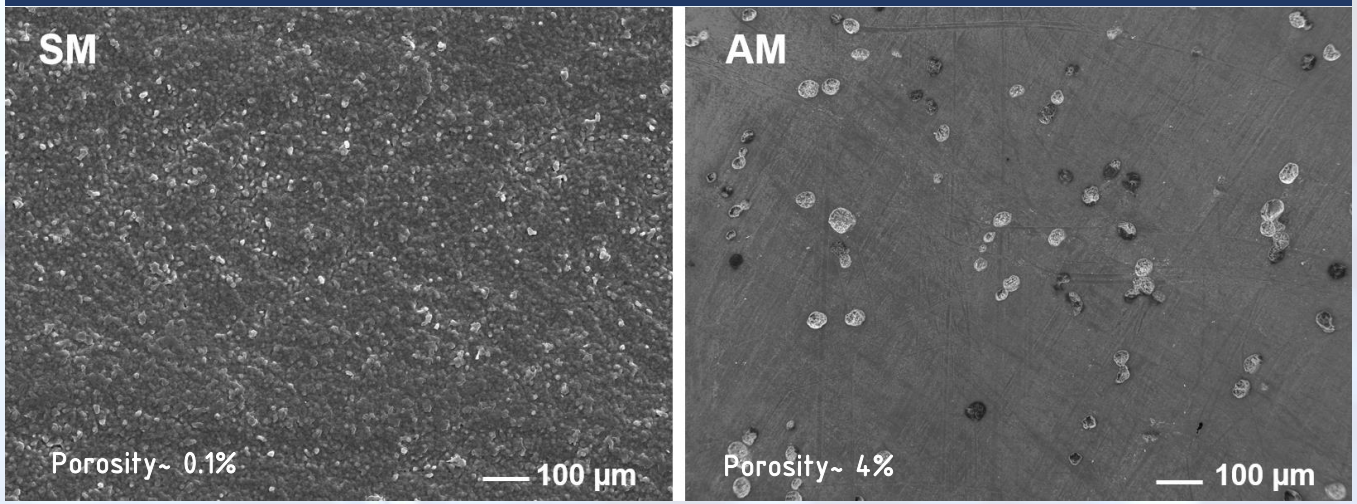
Fracture toughness



Surface roughness

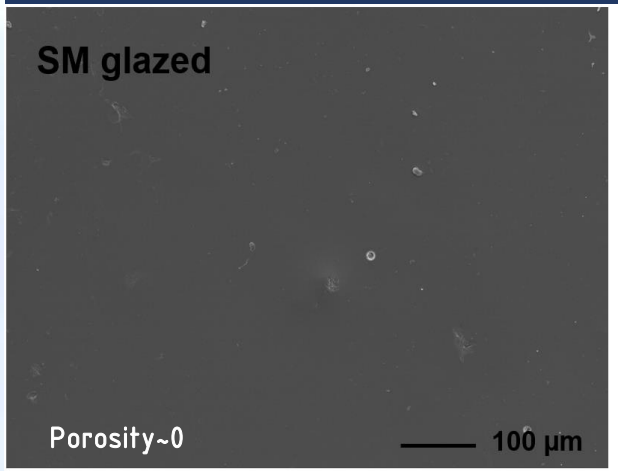


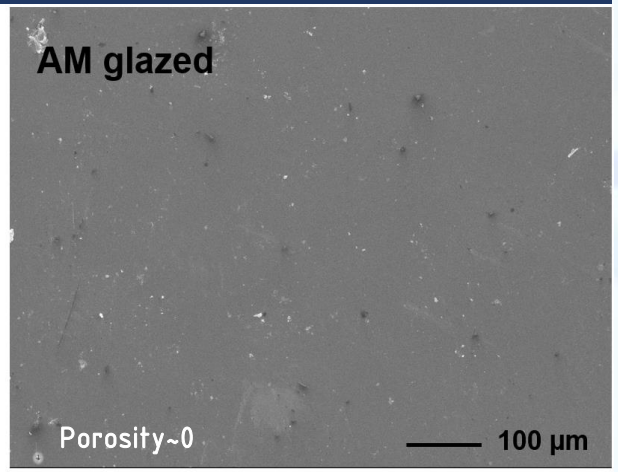
Surface morphology



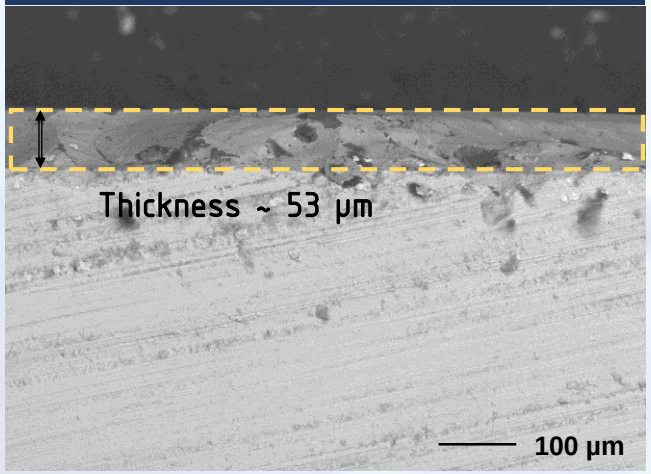
Results: Glaze Characterization

Surface morphology after glazing

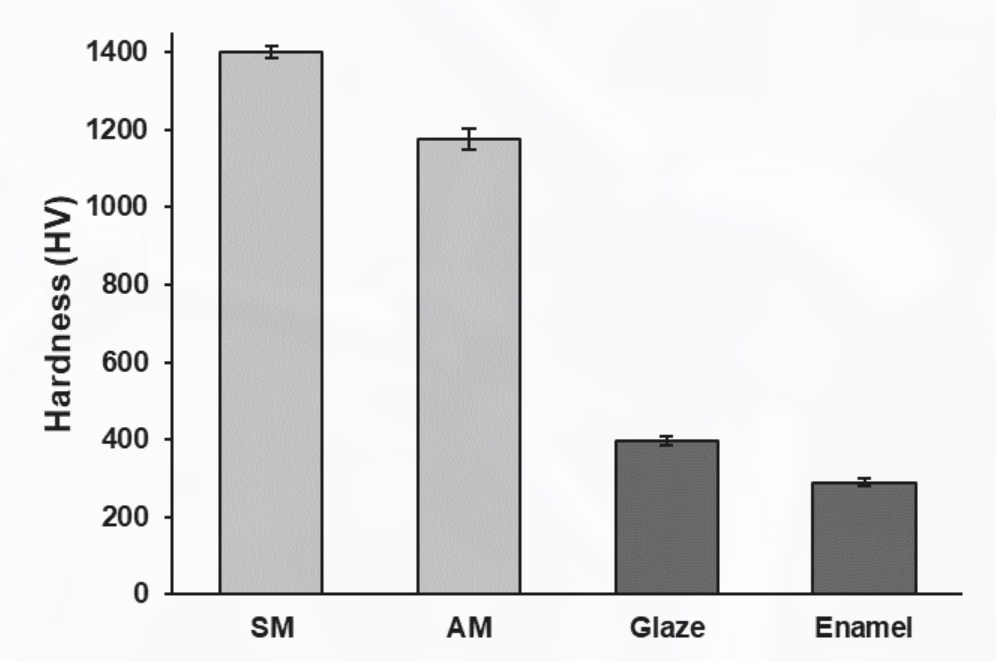




Glaze thickness



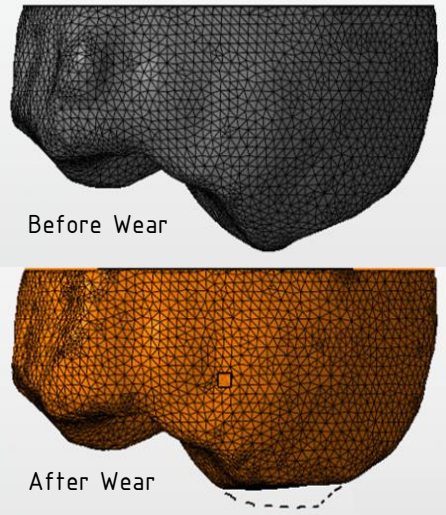
Hardness

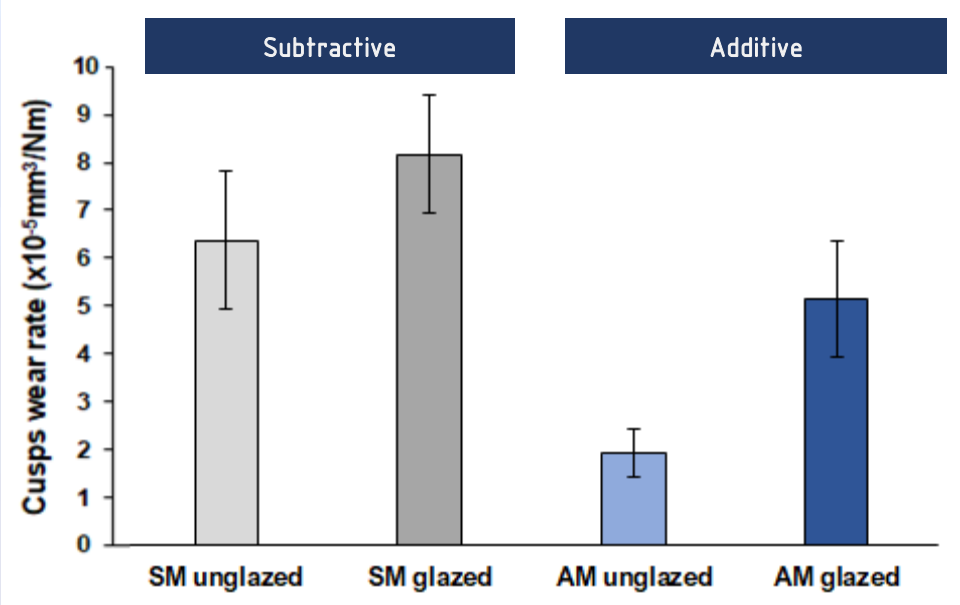


Results: Dental Cusps after Wear Tests

Chewing simulator

Dental wear determination



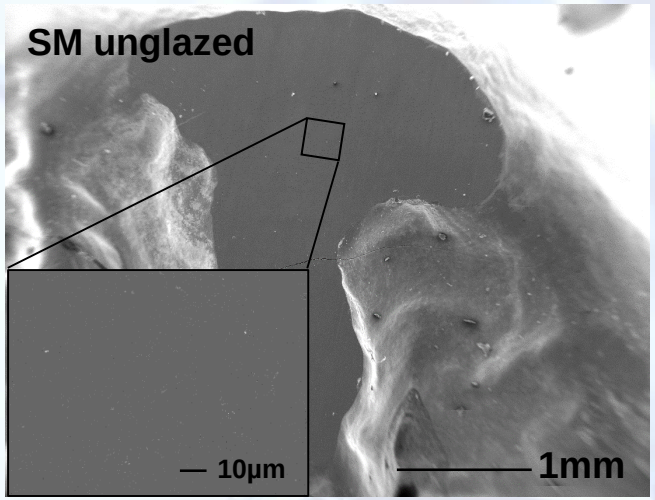


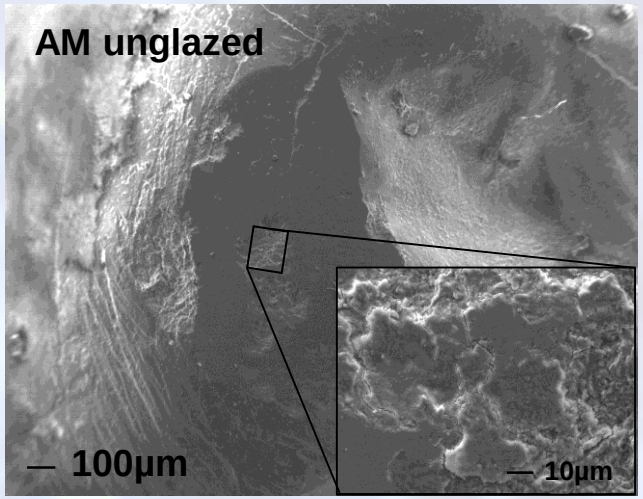
Subtractive

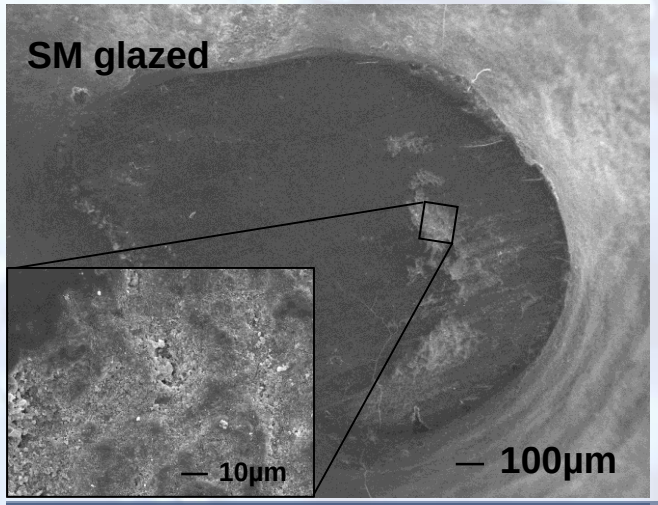
Cusps have a polished appearance without almost any signs of scratches

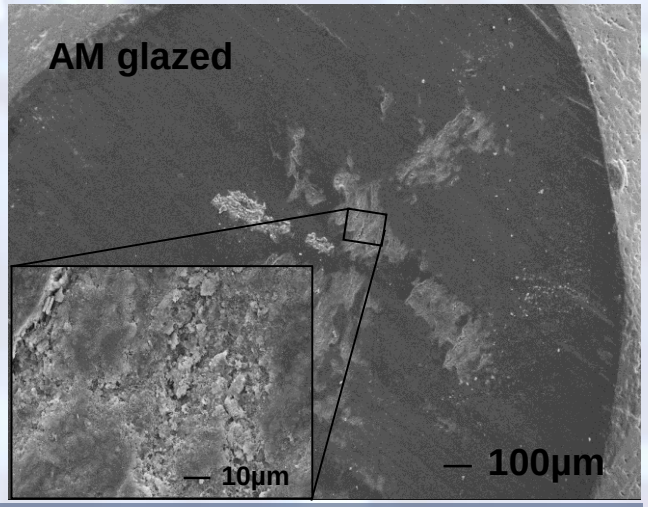
Additive

Cusps present some delamination and adhered dental particles







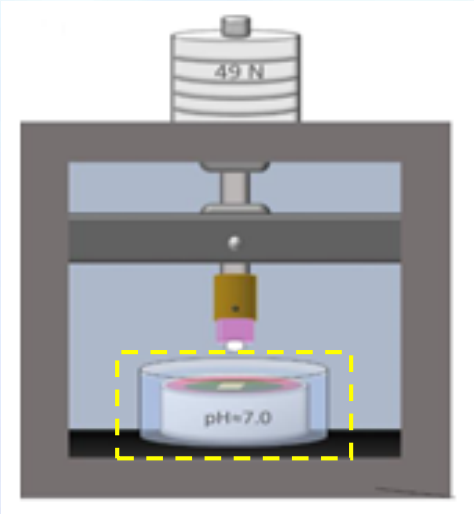


Cusps present scratches, delamination and adhered dental and glaze particles

Cusps present scratches, delamination and adhered dental and glaze particles

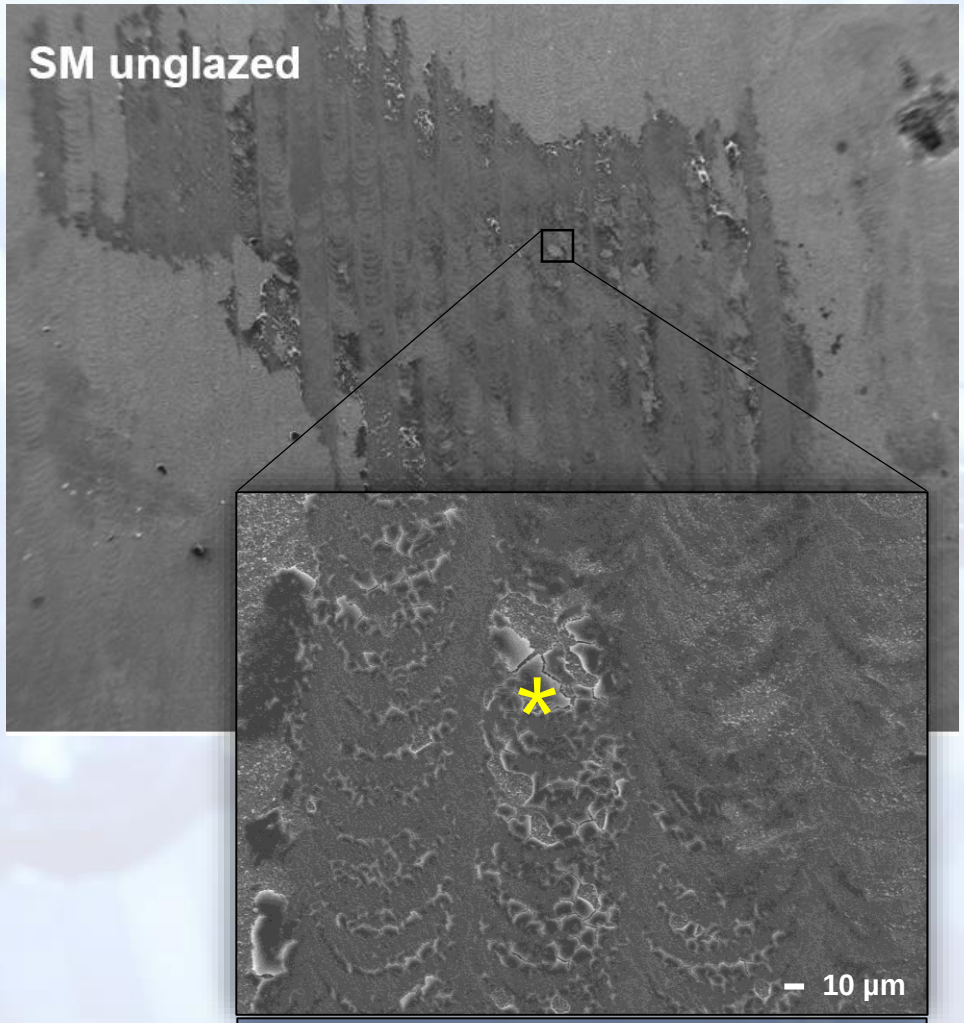
Results: Zirconia Unglazed Samples after Wear Tests

Chewing simulator



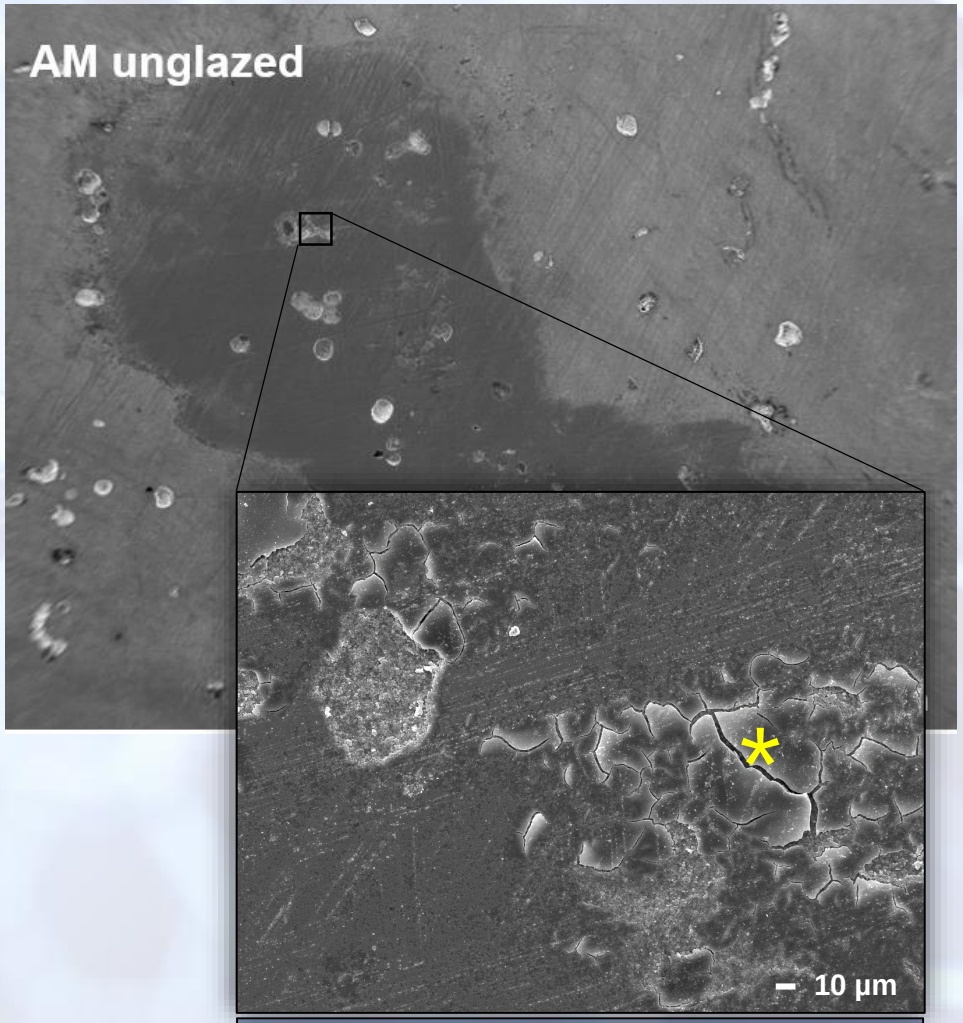
* Dental particles

Subtractive



Surface presents zones with a thick layer of adhered dental material

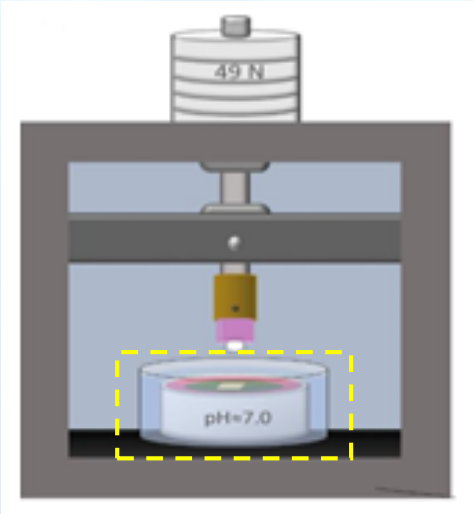
Additive



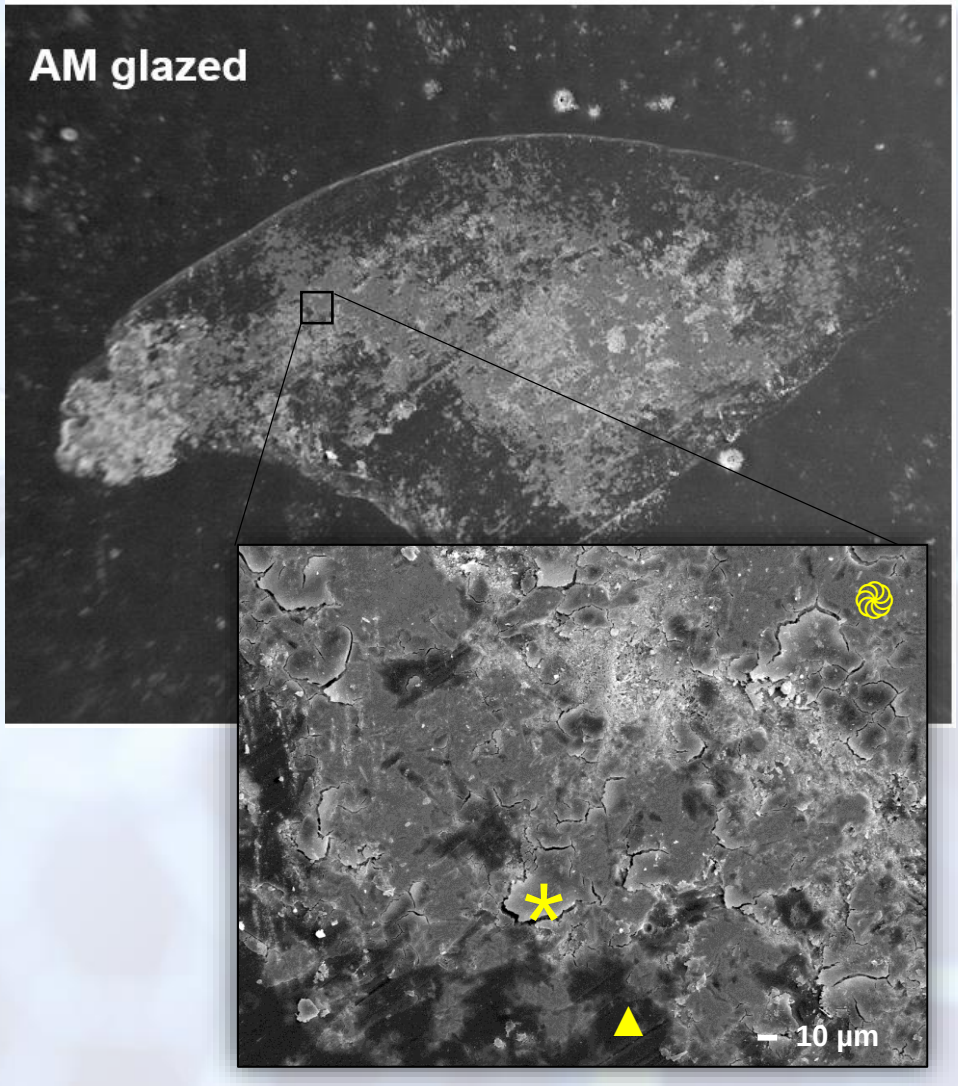
Surface defects in which the worn dental particles preferentially adhered

Results: Zirconia Glazed Samples after Wear Tests

Chewing simulator	Subtractive	Additive



- Zirconia
- Dental particles
- Glaze



- Glaze suffered wear, leaving some zones of zirconia exposed
- Dental particles from the cusps wear adhered to zirconia/glaze
- Some parts of the glaze coating did not suffer wear

Conclusions

Additive manufacturing seems to be a promising technique to produce zirconia dental pieces.

The use of glaze induced a higher cusps' wear.

The wear was higher for the cusps against SM samples (unglazed and glazed).

Thank you!

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