



Selective laser treatments on ceramic and glass ceramic powders for piezoelectric applications

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Purpose

Laser treatments are investigated with the aim to establish **selective and versatile process** for electronic applications. In this research, the behaviors of **barium titanate** powders and **glass powder** under selective laser irradiation are investigated. The purpose is to determine suitable conditions 1) to sinter the powders and to form dense BaTiO₃ thin components 2) for glass ceramic to crystallize a glass coating usable in hybrid circuits.

Laser characteristics

Laser Trumark Station 5000

- Solid-state laser (Nd:YVO₄)
- Max. Power: 22,8 W (cw)
- Wave length: 1064 nm
- Laser Beam: TEM₀₀ (Gaussian)



Laser surface treatment

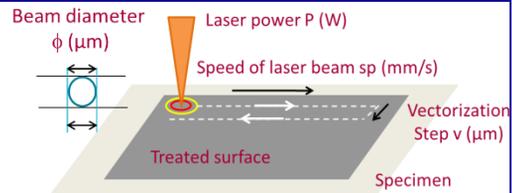
Powder density (W/mm²)

$$\rightarrow P_w = P / \phi^2$$

Interaction time (s)

$$\rightarrow t = \phi / sp$$

Energy density (J/mm²) $\rightarrow J = P / (sp \cdot \phi)$

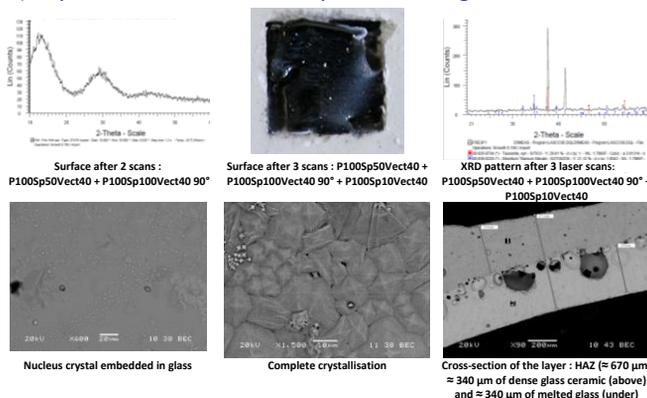


Laser treatment on glass powder compacts

The piezoelectric glass ceramic contains fresnoite crystals (Sr₂TiSi₂O₈) in a glass matrix obtained by crystallization of a parent glass of the SrO-SiO₂-B₂O₃-K₂O-TiO₂-Al₂O₃ system.

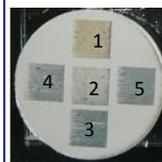
2 steps for the laser treatment:

- 1) Creation of an amorphous homogeneous coating from a parent glass crushed in powder ;
- 2) Crystallization of this amorphous coating.



→ Good devitrification with crystallization of 2 phases: Sr₂TiSi₂O₈ and SrTiO₃.
→ Sr₂TiSi₂O₈ presents textured surface preferential orientation of (001) plans requested.

Laser treatment on ceramic pressed powder (BaTiO₃)

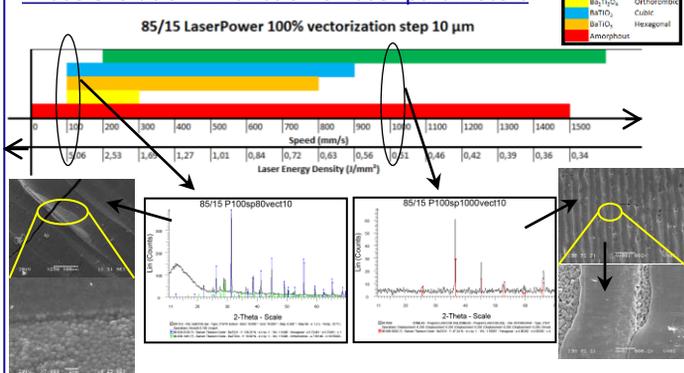


5 squares (1 cm²) lased with different conditions [P95vect20sp100(1) = 4,8 J/mm², sp200(2) = 2,4 J/mm², sp300(3) = 1,6 J/mm², sp400(4) = 1,2 J/mm², sp600(5) = 0,8 J/mm²]

Crystalline phase of BaTiO₃ in fct of temp.

Ortho. → Tetragonal → Cubic → Hex. → liquid
0°C 130°C 1460°C 1650°C

Phase evolution in function of laser parameters



Best results are obtained at high scan speed (> 1000 mm/s) on a powder mixture nano + micro :

- Low ratio liquid/solid (mainly melting of nano grains)
- Growth of the unmelted grains in the liquid phase
- Conservation of the tetragonal BaTiO₃ (low amount of amorphous phase)

Conclusion

- ✓ Devitrification of a large surface of glass was obtained with a process of 3 laser scans. Refining of the laser scan conditions had to be done in order to obtain only crystallization of Sr₂TiSi₂O₈ with correct texturation.
- ✓ Surfaces of consolidated powder with expected crystalline form of BaTiO₃ had been obtained. Impact of the granulometry of the powder on the laser treatment are investigated in order to realize thin coating on substrate.

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