

PULSED LASER DEPOSITION OF HYDROXYLAPATITE THIN FILMS ON BIOMORPHIC SILICON CARBIDE CERAMICS

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AIM

To study the influence of water vapour pressure and temperature on the deposition of hydroxylapatite (HA) thin films by Pulsed Laser Deposition (PLD) on biomorphic SiC ceramics.

INTRODUCTION

COATINGS: HYDROXYLAPATITE

- HA is used as coating of dental and orthopaedic metal implants to improve their biocompatibility.

- Plasma spraying is the commercial coating technique.

Shortcomings:

- ❖ Poor adhesion to the substrate.
- ❖ Production of phases different from HA.

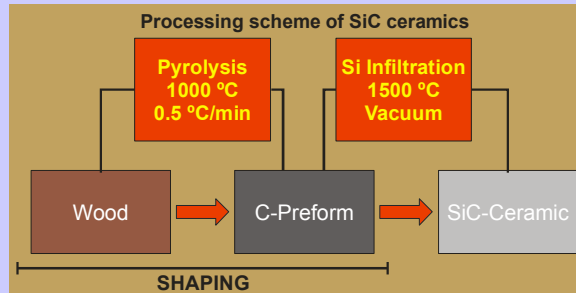
- Pulsed Laser Deposition is an **alternative to Plasma Spraying**.

Advantages:

- ❖ Improved adhesion to substrate.
- ❖ Controlled physical and chemical properties of the coating.

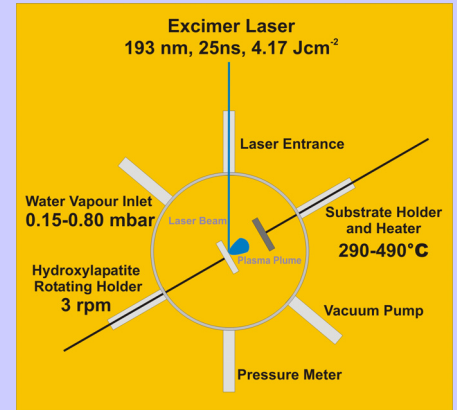
SUBSTRATES: Bio-SiC CERAMICS

- Biomorphic Silicon Carbide ceramics (bio-SiC) can be used as alternative materials for metallic implants, due to low density, biologic inertness, interconnected porosity, and improved mechanical properties.



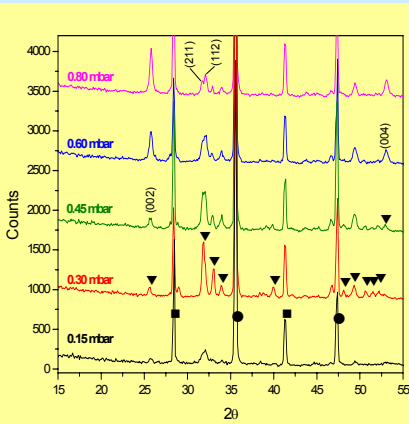
EXPERIMENTAL

Laser Processing Conditions



RESULTS

XRD ANALYSIS



Hydroxylapatite (▼), SiC (●), Silicon (■)

INFLUENCE OF WATER VAPOR PRESSURE

A crystalline carbonated Hydroxylapatite was obtained.

The carbonate ions substitute phosphate groups in the **CHA crystalline structure**:

- XRD: Peaks of (211) and (112) planes are overlapped.
- FTIR: ν_3 and ν_2 vibration modes of carbonate ion are present.

For water pressure increase the carbonate group incorporation is reduced:

- XRD
 - ❖ (211) and (112) peaks are split.
 - ❖ (002) and (004) peaks increase their intensity.
- FTIR: The intensity of carbonate vibration modes is gradually reduced while intensity of phosphate vibration modes increases.

The crystallinity of the CHA is reduced with water pressure increase:

Arrival of the ablation particles is enhanced, and diffusion phenomena are faster than particle accommodation in the network.

INFLUENCE OF SUBSTRATE TEMPERATURE

Crystalline CHA is obtained only for high temperatures ($\geq 460^\circ\text{C}$):

- XRD: No peaks appear under 460°C .
- FTIR: The bands are very broad for low temperatures.

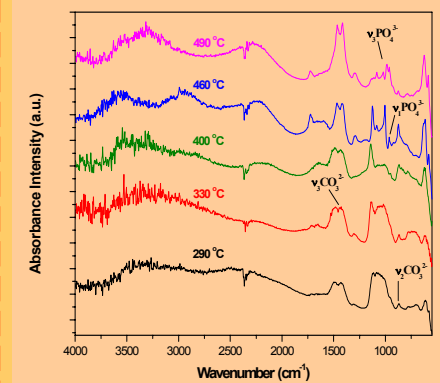
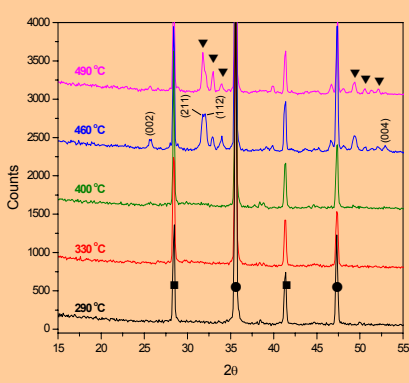
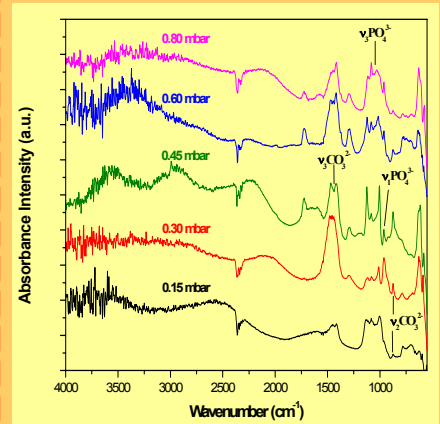
For temperature increase the carbonate groups incorporation is enhanced:

- XRD
 - ❖ (211) and (112) peaks overlap.
 - ❖ (002) and (004) peaks decrease their intensity.
- FTIR: The intensity of carbonate vibration modes increases gradually while intensity of phosphate vibration modes decreases.

With temperature increase:

- A preferential desorption of phosphorous atoms for high temperatures and substitution by carbonate explain the Ca/P ratio variations and increase of carbonate content on the coatings.

FTIR ANALYSIS



XPS ANALYSIS

| Temperature (°C) | Ca/P ratio |
|------------------|------------|
| 290 | 1.54 |
| 330 | 1.53 |
| 400 | 1.82 |
| 460 | 1.73 |

CONCLUSION

- Biomorphic SiC ceramics have been successfully coated with carbonated hydroxylapatite by PLD in water atmosphere.

- The crystallinity grade and the phosphate to carbonate content ratio can be modulated by the substrate temperature and the gas pressure.

ACKNOWLEDGEMENTS

