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Hydroxyapatites of marine origin as sustainable candidates for implantology

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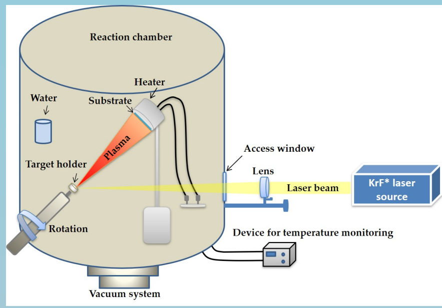
Motivation

- Development of implants easily integrated into the living body by using biomaterials.
- Route to obtain a material with a bone-like architecture and composition → fabricate it from sustainable resources, of biological origin, such as waste products (*i.e.*, HA derived from fish bones, FB, or sea-shells).
- Synthesis by PLD of bio-hydroxyapatite thin films (doping with 0.5, 1 and 2 wt.% of Li_3PO_4, MgF_2 and Ag).
- Detailed morphological, structural, compositional and mechanical investigations → beneficial influence of doping agents on the characteristics of the synthesized structures.

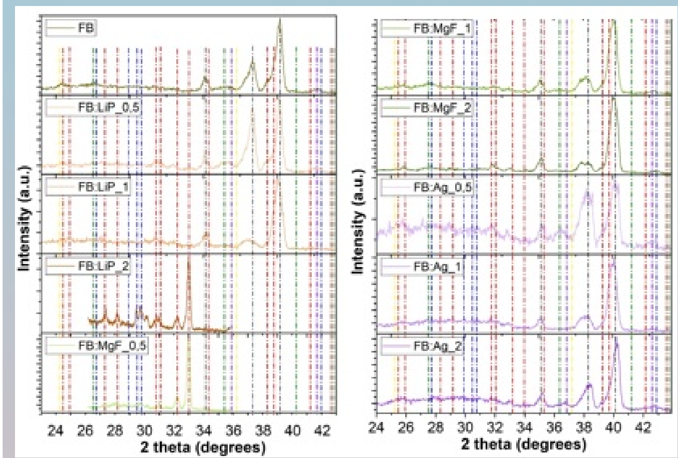
Materials and Methods

- PLD experiments, KrF* excimer laser source (λ = 248nm, $\tau_{FWHM} \leq$ 25ns, ν = 10Hz), deposition parameters (p ≈ 50 Pa, H_2O vapors, d = 5 cm, E = 360 mJ, T = 500°C, F = 3.5 J/cm^2, N = 5000).
- Simple (FB) and doped (with 0.5, 1 and 2 wt.% of Li_3PO_4, MgF_2 and Ag → FB:LiP, FB:MgF and FB:Ag).

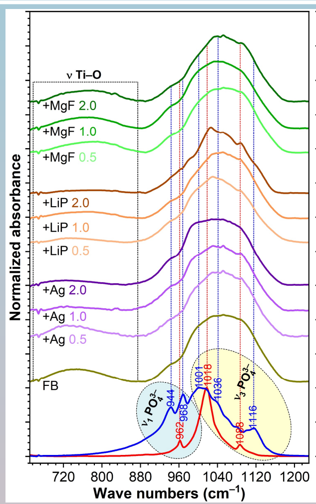


PLD experimental set-up

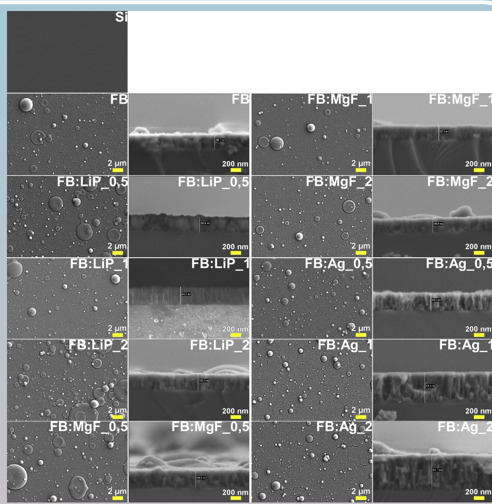
Results



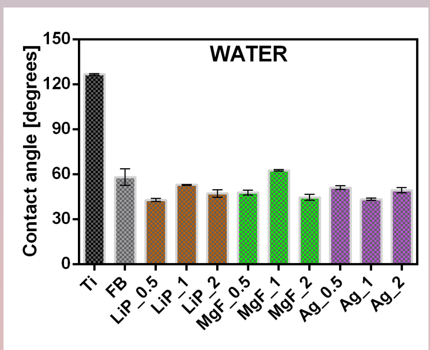
XRD diffractograms of simple and doped bio-hydroxyapatite thin films. Peaks were highlighted as following: Ti (grey), TiO_2 rutile (green), TiO_2 anatase (yellow), TiO (violet), $Ca_3(PO_4)_2$ whitlockite (blue) and $Ca_5(PO_4)_3(OH)$ (red).



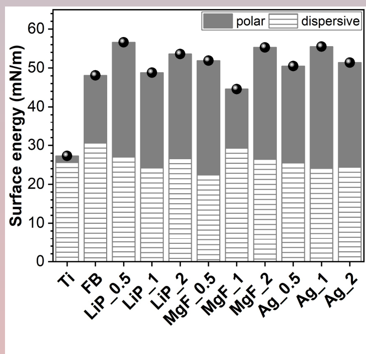
FT-IR spectra of simple and doped bio-hydroxyapatite thin films.



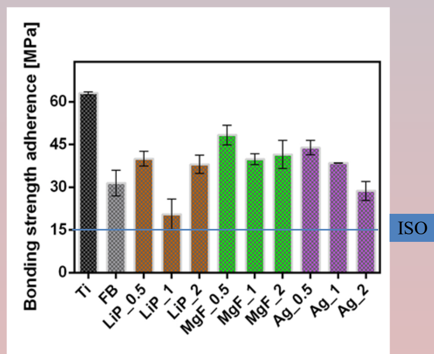
Top-view and cross-view SEM micrographs of simple and doped bio-hydroxyapatite thin films. Magnification bars: 2 µm (top-view) and 200 nm (cross-view).



Contact angle values inferred for simple and doped bio-hydroxyapatite coatings.



Surface free energy values inferred for Ti, and simple and doped bio-hydroxyapatite thin films (γ_d – hatched region, γ_p – grey region).



Pull out bonding strength adherence values measured in the case of simple and doped bio-hydroxyapatite thin films.

Conclusions

- **Structural investigations → synthesis of films with different degrees of crystallinity, mainly influenced by the nature of the dopant/concentration and by the source material;**
- **Morphological examination → fabrication of films with rough surfaces, made of droplets, ideal for the good adhesion of cells and anchorage of implants *in situ;***
- **Contact angle measurements → hydrophilic behaviour→ rapid bone regeneration;**
- **Bonding strength adherence → values more than three times higher than the threshold imposed by ISO standard regulating the load-bearing implant coatings (>15 MPa);**
- **Preliminary results → incorporation of dopants into BioHA thin films can provide a delivery system for bioactive agents able to promote osseointegration, in correlation with an improved anchorage of bone metallic implants for suitable use in implantology.**

Acknowledgements

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