Study of the stoichiometry transfer in pulsed laser deposition of bioactive silica based glasses

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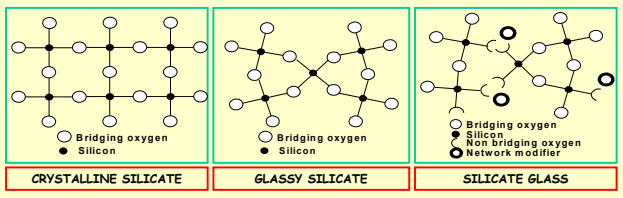
INTRODUCTION

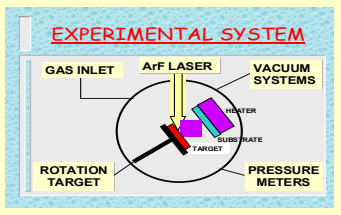
BIOACTIVE GLASSES

- Bioactive glasses are of great interest for medical applications.
- Implants coated with bioactive glass would be beneficial to improve the fixation and osteointegration of biomedical devices.
- Bioactive glass is highly reactive when exposed to body fluids, which results in the formation of a bond between tissue and material through a firm calcium phosphate layer.
- PLD is a good candidate as a bioactive glass coating method due to their unique characteristic to transfer materials with complex stoichiometry.
- The composition of the coatings is a crucial point in order to obtain an adequate biological response.



EXPERIMENTAL

LASER ABLATION PARAMETERS



- Ar F excimer laser: λ = 193 nm; E = 4,17 J/cm^2
- Target-substrate distance: 35 mm
- Substrate temperature: 200 ºC
- Film thickness: 2 µm
- Residual pressure: 10^{-5} mbar

TARGET MATERIALS

	Na_2O	K_2O	CaO	P_2O_5	MgO	B_2O_3	SiO_2
Bulk 42	20	10	20	3	5	-	42
Bulk 50	15	15	15	-	2	3	50
Bulk 55	21	9	8	4	2	1	55
Bulk 59	10	5	15	3	5	3	59

Composition in wt% of the glasses used as ablation targets

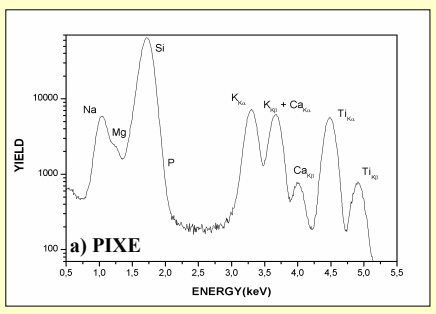
CHARACTERIZATION TECHNIQUES

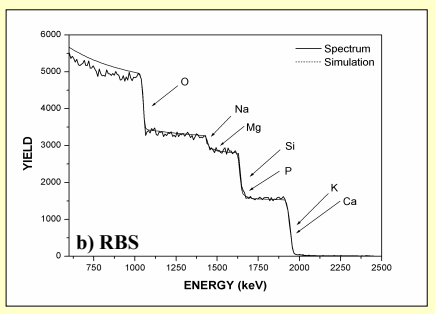
- Rutherford Backscattering Spectrometry (RBS)
- Particle Induced X-Ray Emission (PIXE)
- Nuclear Reaction Analysis (NRA)
- Fourier Transform Infrared Spectroscopy (FTIR)
- X-ray Induced Photoelectron Spectroscopy (XPS)

RESULTS

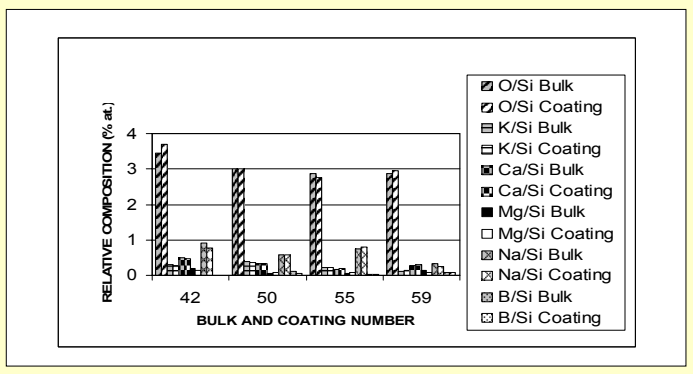
A) TRANSFER OF THE TARGET STOICHIOMETRY

ION BEAM ANALYSIS





Typical PIXE and RBS spectra of a bioactive glass coating.



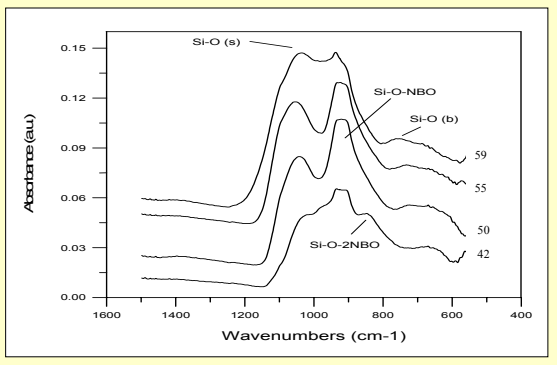
Relative composition of the bulk and PLD bioactive glass coatings determined by Ion Beam Analysis Techniques (RBS, PIXE and NRA).

THE TARGET STOICHIOMETRY IS NEARLY CONGRUENTLY TRANSFERRED TO THE COATINGS !!!

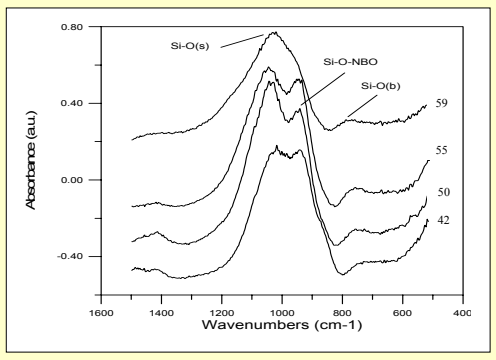
B) TRANSFER OF THE TARGET BONDING CONFIGURATION

FTIR SPECTRA

BULK GLASSES



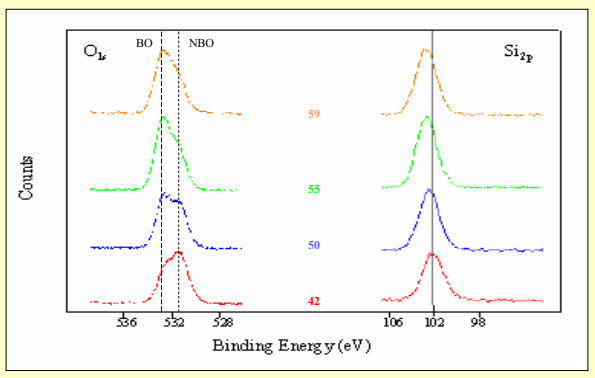
GLASS COATINGS



Infrared absorbance spectra of bulk and bioactive glass coatings obtained by PLD from the ablation of the corresponding bulk glass. Different bands associated with Si-O bridging oxygen and non-bridging oxygen (Si-O-NBO) groups have been identified.

XPS SPECTRA

GLASS COATINGS



	Si2p	O1s (NBO)	O1s (BO)
Coating 42	102,08	530,73	532,33
Coating 50	102,44	530,82	532,53
Coating 55	102,65	531,08	532,67
Coating 59	102,72	531,06	532,64

XPS binding energies (eV) of the Si2p and O1s photoelectrons for different bioactive glass coatings. The positions attributed to the Si-O-Si vibration (bridging oxygen groups, BO) and the non-bridging Si-O groups (NBO) are depicted.

THE TARGET BONDING CONFIGURATION IS NOT TRANSFERRED TO THE COATINGS !!!

CONCLUSIONS

- Pulsed laser deposition is a promising technique to produce bioactive coatings.
- The composition measurements by Ion Beam Techniques demonstrate that the complex stoichiometry of the glass is successfully transferred to the coating.
- FTIR and XPS analysis show important changes in the film bonding configuration in comparison with the bulk target material.
- This effect plays a key role in the bioactive behaviour of the coatings.
- This study contributes to the development and tailoring of PLD bioactive glass films with an optimun bioactivity for medical applications.