Surface analysis on thin films deposited on different substrates

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Short presentation of the scientific project

Hydroxyapatite (HAp, $Ca_{10}(PO_4)_6(OH)_2$) is a biomaterial with a wide range of applications in medicine due to its biocompatibility, bioactivity and osteoconductivity.[1-4] Hydroxyapatite has been used to fill a wide range of bony defects in orthopaedic and maxillofacial surgeries and dentistry.[5-8] It has also been widely used as a coating for metallic prostheses to improve their biological properties.[9-11] Regarding the sintering under ambient conditions, the decomposition has been reported to begin in the range 600-1100°C, however, some materials have been observed to be resistant to decomposition until 1200°C.

The polydimethylsiloxane (PDMS) is an elastomer with biocompatible properties and is frequently used as substrate for biological studies.[12-13] The hydrophobic character of a PDMS layer, due to the methyl groups present on its surface, makes it suitable for non-adherent cell culture studies.[14] On the other hand, PDMS oxidized hydrophilic surfaces, produced by different treatment methods[14], more SiO_2 like surfaces, highly favour the cells adhesion. PDMS is the most widely used silicon-based organic polymer, and is particularly known for its unusual rheological (or flow) properties. PDMS is optically clear, and, in general, inert, non-toxic, and non-flammable. The chemical formula for PDMS is $CH_3[Si(CH_3)_2O]_nSi(CH_3)_3$, where n is the number of repeating monomer $[SiO(CH_3)_2]$ units.

Deposition of PDMS polymer layer on commercially pure Si disks

The experimental set-up consists in a point to plane corona discharge electrode configuration. By placing a quantity of 0.1 μl of a vinyl- terminated/hydroxyl-terminated PDMS liquid precursor (provided by Sigma Aldrich Company) on the disk electrode, a liquid film with an average thickness of 127 nm across a surface of 10 mm in diameter was formed. After 2 hours a solid polymer layer is formed on the 10 mm surface of the silicon substrate.

Synthesis of hydroxyapatite powder

In order to synthesize the silver doped hydroxyapatite (HAp) by coprecipitation methods the precursors of calcium nitrate [$Ca(NO_3)_2 \cdot 4H_2O$, Aldrich, USA], ammonium hydrogen phosphate ($(NH_4)_2HPO_4$; Wako Pure Chemical Industries Ltd.) and $AgNO_3$ (Alpha Aesare, Germany, 99.99% purity) were used. The hydroxyapatite nanoparticles were prepared by setting the atomic ratio of Ca/P at 1.67.

Deposition of HAp nanoparticles on a silicon substrate previously coated with a PDMS layer

The HAp powder treated at a temperature of 800^0C for 6 hours has been deposited by thermal evaporation technique as solid layer on a silicon substrate previously coated with a PDMS layer. By this technique the HAp nanoparticles, (source material) are evaporated in vacuum. The Ag:HAp powder evaporation temperature was 1100^0C.

The calculated thickness of HAp layer deposited, in the experimental conditions presented above, on a silicon substrate is about 480 nm. In the presence of a PDMS layer on the substrate, the HAp; evaporated particles diffuse into the PDMS layer during their travel to the substrate. When the HAp particles stops in the polymer layer they transfer their energy to the polymer. Thus, the local temperature increases and as the polymer is heated the thermal condition of a new compound generation is assured. The HAp thin film thickness is around 150 nm on PDMS layer.

Samples characterizations

- Determination of the Ca, P, C, Si, H content of the thin films by RBS, PIXE and ERDA methods.
- Determinations of Ca/P molar ratio

InGe ohmic contacts on GaAs SI

InGe metal deposition on GaAs SI followed by a thermal annealing procedure is a method of obtaining ohmic contacts on this type of semiconductor. Once the fabrication process is established (etching method of the surface, thickness of each metal, annealing time and temperature), this method is relatively simple and has excellent reproducibility.

Obtaining low resistance ohmic contacts is based on the formation of an intermediate semiconductor layer (ISL) at the GaAs surface characterized by a low energy barrier and a high carrier density. The high carrier density is due to heavy Ge doping at the metal/GaAs interface, while the low energy barrier appear due to formation of $In_xGa_{1-x}As$ type compounds which has an energy gap and Schottky barrier less than those of GaAs. Increasing In concentration x, the energy gap decrease, reaching 0.4eV for InAs compound, while the Schottky barrier become 0 at a value of x=0.7. Reduction of contact resistance value to a level of $10^{-6}\Omega cm^2$ is achievable by this technique. Adding gold (Au) in the metallic alloy further eases the Ga diffusion from the semiconductor surface and Ge doping of the interface.

Therefore, the investigation of chemical composition of both surface layers and metal/semiconductor interface is of vital importance.

Our sample:

Deposition 30nm In 30nm Ge 30nm Au

Annealing 440°C for 5 minutes.

Ohmic contacts on GaSb

Among III-V semiconductors GaSb-based materials are preferred because their bandgap covers a wide energy range and suit well the emission wavelength band of low temperature $(1000\text{-}1400)^0$C selective radiators. The binary GaSb is mostly used as substrate for both epitaxial

and diffused junction TPV devices or even Schottky barrier devices. The problems related to the formation of ohmic contacts on *n* and *p*-GaSb represents a technological problem considered in general a real state-of-art in obtaining semiconductor devices. It was established[15] that the minimization of contact resistivity was respectively obtained with Au-Zn on p-type and Au-Te on n-type GaSb due to the appearance of an over-doped layer at the semiconductor surface. The experiments proposed for ohmic contact on p-type semiconductor alloys of Au and Ag for a resistivity 10^{-4}-$10^{-6}\Omega$cm , or different sequences as Cr/Au, Ti/Pt/Au , followed by an annealing process $(250\text{-}350)^0$C for 10-30 min. The effect of the removal of native oxide on GaSb will be studied both by XPS procedure and nuclear methods. For ohmic contact on n-GaSb we propose the experimental study of Au, AuTe or AuSn and the expectation is a contact resistivity of 0.5-$1x10^{-4}\Omega$cm, after an annealing process at 300^0C for 5 min. The samples prepared in this technology will be subjected to different surface analysis techniques (XPS, SEM, AFM) including nuclear procedures in order to establish the composition and quality of thin layer contact (100-150 nm).

We need 5days (15 shifts) at 3 MV Tandetron and 5 days (15 shifts) at the 9 MV Tandem.

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