Nanostructured biomaterial thin films synthesized by pulsed laser technologies: new applications to implantology (II)

This limit was surpassed by new deposition technologies, i. e. Matrix Assisted Pulsed Laser Evaporation (MAPLE) and Matrix Assisted Pulsed Laser Evaporation - Direct Writing (MAPLE DW), able to successfully transfer organic and biological materials from cryogenic targets [3,4]. In Romania these techniques were developed for the first time by LSPI laboratory, after 2003.

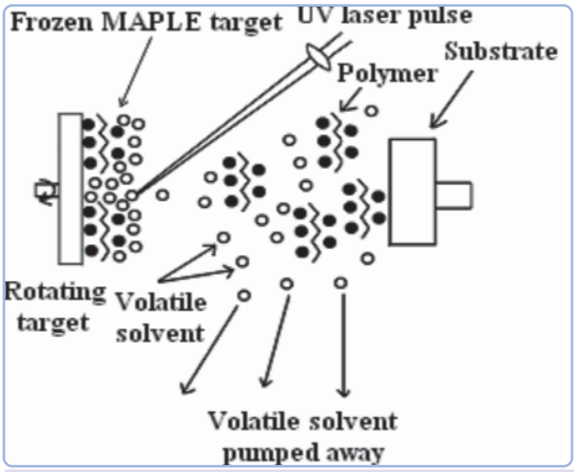

Fig. 2 Schematic representation of MAPLE process

In MAPLE (Fig 2), the simultaneous evaporation of the frozen target and ejection of the organic or biologic material are initiated. The photon energy absorbed by the solvent is converted to thermal energy that causes the organic or biological material be expulsed under the protection of frozen solvent, which is gradually vaporized and evacuated by pumping. The delicate material molecules reach sufficient kinetic energy by collective collisions with the evaporating solvent molecules, to be transferred in gas phase.

Recent literature data predicted that MAPLE and MAPLE-DW will be indispensable in the development of next generation microfluidic biosensors and biochips, coating drug particles with functional polymers, microneedle coatings for various therapeutic applications (DNA vaccines, gene therapy) or biocompatible coatings for medical implants.

In our experiments, the radiation generated by a KrF* excimer laser source (λ=248 nm, T=25 ns, v=(1-50)Hz) was focused onto the cryogenic composite target surface.

Very recently, we succeeded to synthesize by MAPLE new inorganic-organic (ceramic-polymer) hybrid thin films, directly onto the surface of the metal implants.

The composite material prevalently contained (80% w. p.) hydroxyapatite, the main component of the bone tissues.

A synthetic organic polymer (maleic anhydride copolymer) was added (20% w. p.) to induce the coating surface functionalization and improve mechanical properties.

All deposited samples were subjected to physical investigations (XRD, SEM, FTIR) and in vitro biological characterizations. The results indicated that the optimum deposition regime for an appropriate stoichiometric and functional transfer was obtained for 0.55 J/cm^2 laser fluence, 30 °C substrate temperature, 26 Pa N_2 and 3 cm target-substrate separation distance.

In vitro tests demonstrated that Ti coated with hybrid HA-polymer exhibit excellent biocompatible behaviour. Fluorescence microscopy studies of human embryonic kidney (HEK293) cells grown on HA-polymer coatings show a surface occupancy comparable to the control (Fig 3).

The hybrid biomaterials films proved a better biocompatibility than simple HA films, enhancing even more the adhesion and

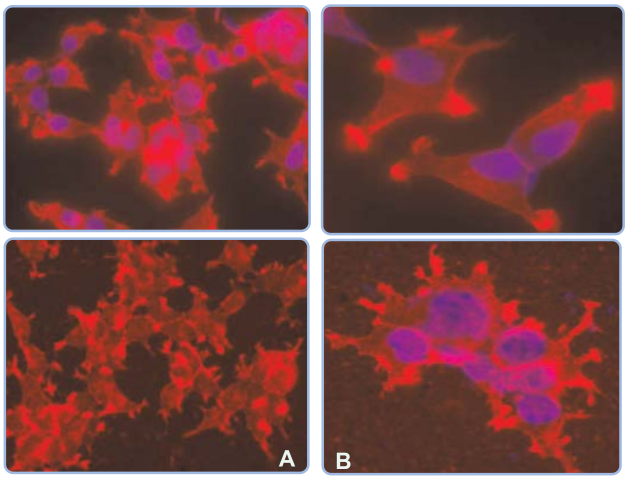

Fig. 3: Fluorescence microscopy images of Hek293 cells grown on HA - maleic anhydride copolymer thin film (A) and on standard glass material (B), respectively;

proliferation performances of implant surface (Fig 4). The cells presented normal morphology, good adhesion, and, spreading as it is evidenced by actin filament organization, cell-cell contacts and uniform covering of the substrate.

In vivo biological studies of the new structures are in progress.

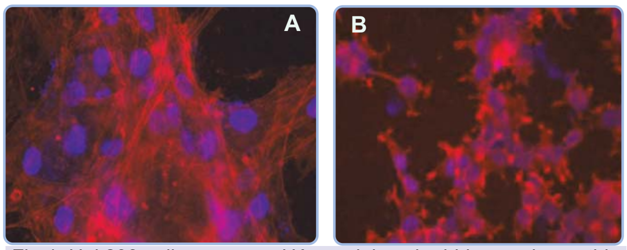

Fig.4: Hek293 cells grown on HA - maleic anhydride copolymer thin film (a), and on simple HA thin film (b)

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