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BIOCOMPATIBLE NANOSTRUCTURE MATERIALS

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Abstract

Materials suitable for medical systems have always been the product of interdisciplinary collaboration between material and biological science. As well as different area of physics and chemistry. For medical application materials must not damage blood cells or bones and must be resistant. Some implant materials for chemical bonds can be stabilized by implantation of different elements or deposition of very thin films. In this work we presented some results for replacement of damaged human tissues.

Introduction

Material scientists and engineers are now developing new processing methods that require little or no reliance on imported materials and yield more efficient and cost effective products. No single synthetic materials has satisfied all biocompatibility requirements but several substances have provided to be usable. Progress has been great .New polymers , ceramics, glasses and composites are among the many materials now enabling medical engineers to design innovative , and increasingly biocompatible, replacements for damaged human tissues. A rapid development in recent years has been derived from the large number of grain bounderies compared to large fraction of atoms at the surface on nanocrystaline materials.[1]

One of the most important characteristics of nanoparticles is their high surface to volume ratio and consequently large fraction of surface atoms. Because of large fractions of surface atoms nanoparticles exhibit distinctly different properties comparing to the bulk of the same chemical composition. When the concentration of atoms or ions in solids became sufficiently high they aggregate in to small clusters. This clusters coalesce and grow to form larger cluster assembly. Thus, the nanoparticles are often built-up from a full-shell cluster of atoms having cubic or hexagonal closed-packed structure. Such a structure can be constructed from a central atom surrounded by a first shell of 12, a second of 42, at third of 92 atoms, etc.[2]

Materials suitable for medical application have always been the results of interdisciplinary collaborations among investigators in materials science, bioengineering, biological science and clinical medicine. The success application of new biocompatible materials depends especially on progress in discovering properties of materials particularly the properties of the surface. The progress in vacuum science and techniques of characterization will help us in development of new biocompatible materials. At present biomaterials are important for application from intraocular lens replacement to artificial hearts. The progress has been so great that we can not describe promising systems and materials on the market or under studies. We shall therefore limit ourselves to several examples of medical system developed in Laboratory of Atomic Physics in Vinca Institute of Nuclear Sciences. To be acceptable as a biomaterial a substance must pas chemical and mechanical studies and has to be biocompatible. It means that it must interact with human tissue in a nontoxic , controlled and predictable way. In our laboratory we have made a lot of experiments with osseous , or bones, dental implants and stents used in cardio surgery.

Results

Significant progress has been made in understanding of different aspects of synthesis of nanomaterials, nanoparticles and the commercial products . New technology includes a wide range of vapor liquid and solid state processing roads.

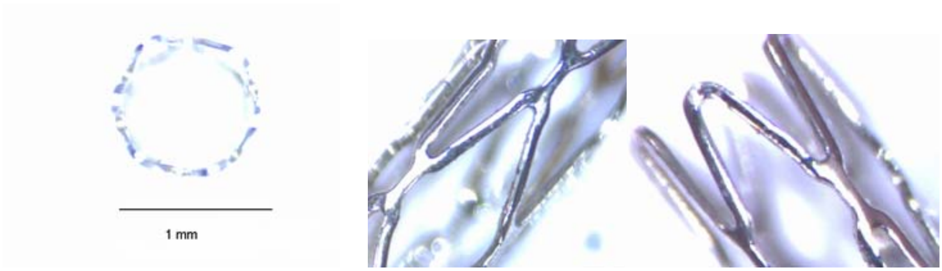
Materials for osseous or bone implants must be rigid and stress resistant . Bone implant should ideally reside in the bone without interfering with bone remineralization and must have the surface without changes and damaged zone. Because of that the bone surface must be prepared by electrochemical polishing or CVD preparation, ion beam preparation of bone surface and PVD preparation technique and by implantation. Metallic prostheses are usually used for orthopedic and as dental implants. On the figure 1 artificial hip joint is presented. The surface of the bone is prepared by mechanical polishing and because of that patient has problem with two surface layers (destroyed surface layers and deformed surface layer).

Fig. 1. Artificial hip joint prepared only by mechanical polishing of the surface.

They are made from chrome or cobalt alloys (steels) or titanium alloys. Bio material infection can be a serious problem for clinical application of implanted biomedical material. In contact with living materials at the surface it is an easy channel for bacterial proliferation. To prevent adhesion and colonization of biomaterials some experiments are focused on modification of implant surface by ion implantation.[3]

Some good results are obtained for dental implants. Implants are made from nanostructure titanium alloys (Ti,Al,V). Because of the infection and rejection risk metallic dental implants do sometimes inflammatory reaction at the implant side.

For cardiovascular systems materials have to be elastic and blood compatible. The earliest medical heart valve were made from stainless steel and silicon rubber. These material were durable but anticoagulant treatment was necessary to prevent blood clot formation. On figure 2 cardiovascular stent is presented.



a) *b)* *c)*

Fig.2. (a-c) Cardiovascular stent: a- stent diameter 1 mm(top view) , b and c – length structure (magnification 20 x).

There is a great interest for the human skin and musculoskeletal system. The replacement of this parts of human body have particular importance in material science. [4]

Conclusion

Decision of choosing one material rather than another can be made in quantitative terms. In these work we are presented only the results obtained in our laboratory concerning hip joints, dental implants and cardiovascular stent.

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