Gas plasma precision cleaning, sterilization and surface activation of orthopedic implants promotes biocompatibility in a single, highly reproducible process step.

By Dr. Demetri Chrysostomou, Director of Technology, PVA TePla America, Inc.

Materials used for orthopedic implants are typically inert metals/alloys, ceramics and polymers. Their surface properties are engineered to encourage osteo-integration, while surface cleanliness and sterility are critical for avoiding inflammatory responses. Indeed, for implanted medical devices, achieving and maintaining surface cleanliness at the molecular level demands careful attention and exhaustive procedures.

Plasma processing is capable of removing organic contamination at the molecular level subsequent to machining, tooling and wet chemical processing steps. Plasma cleaning acts on surfaces in a conformal fashion, not only for substrates of complex geometries but also on textured surfaces with “rough” topographies. Plasma has also been shown to increase surface bioactivity, particularly on organic tissue scaffolds.

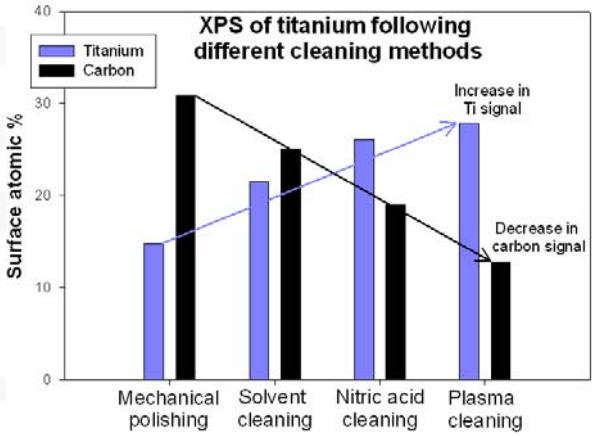
What is plasma?

Plasma is a state of matter just as a solid, liquid or gas. Add enough energy to a gas and it becomes ionized into the plasma state. Chemically it is a highly reactive environment that is used to change the properties of surfaces without affecting the bulk material.

In PVA TePla America's plasma systems, we generate plasma by using electrical energy. This excitation process produces a soup of chemically active species at ambient temperatures that can induce chemical reactions on the surfaces of materials that are not possible under normal conditions. The collective properties of these highly active species can be controlled and harnessed to perform various surface treatments such as precision cleaning, activation, chemical functionalizing, coating deposition etc. PVA TePla America's expertise is in the way we control the properties of the plasma.

Precision plasma surface cleaning

Using x-ray photoelectron spectroscopy, elemental surface atomic species were measured on titanium as a function of different cleaning methods. High signals from carbon indicate high levels of organic contamination, where as high signals from titanium indicate a clean surface.



Bar chart showing relative atomic percentages of carbon and titanium as a function of different cleaning procedures. Data taken from M. Wieland, Ph.D. Thesis, (1999) Swiss Federal Institute of Technology, Zurich

From the graph above it is clear that the highest signal from titanium, and the lowest signal from surface carbon both come from the plasma treated surface. For this reason plasma is ideally used for precision cleaning titanium and Co/Cr alloys after tooling and polishing implant devices. Likewise, plasma is used to clean PEEK materials after tooling and deburring. In this case plasma has a particular advantage as a cleaning technology over wet chemical methods since solvents can cause PEEK to swell thus contaminating the bulk material

Plasma sterilization
The method used to sterilize orthopaedic materials has been shown to have an affect on their long term wear properties. For example, wear characteristics of ultra high molecular weight polyethylene (UHMWPE), used in the manufacture of acetabular liners, are adversely altered by gamma irradiation in presence of oxygen. In low O_2 atmospheres gamma irradiated UHMWPE avoids immediate oxidation and even crosslinks the surface resulting in increased wear resistance. However long-term oxidation of free radicals markedly reduces wear resistance. Plasma sterilization avoids immediate and long term oxidative degradation wear characteristics.

PVA TePla's large plasma sterilization system

Promotion of cell adhesion to scaffolds
NH_3 plasma enhances cell affinity to porous polyactone scaffolds. Studies show cell seeding efficiency can be maintained above 99%, which is better than that achieved by prewetting with ethanol. Scaffold hydrophobicity inhibits cells from penetrating into pores. Plasma solves this problem by surface grafting of amino functionality.

Summary
Gas plasma processing is a powerful tool in solving surface preparation problems for the orthopedic industry. It provides a reliable, consistent, and environmentally friendly method of precision surface cleaning, surface sterilization and activation towards biocompatibility.

What does PVA TePla America offer?
At PVA TePla America we offer a full line of vacuum and atmospheric gas plasma systems. Our reliable, easy-to-operate products deliver some of the most advanced and innovative solutions in the world for a wide variety of industrial applications. We also offer clean area contract processing services with ISO 9001:2000 certification. We are experienced conducting FDA trials and developing CFR Part 11 compliant software.
Additionally, we offer free proof of processing as an incentive to evaluate our plasma technology. This allows you to access gas plasma technology without up front capital expenditure on labor and/or facilities.

Contract plasma treatment lab at PVA TePla America in Corona, California

PVA TePla America Inc. Headquarters

251 Corporate Terrace
Corona, CA 92879-6000
www.pvateplaamerica.com
business: 951.371.2500
sales: 800.527.5667
fax: 951.371.9792