

Surface modification of biomaterials from an academic research perspective

[J. Gold](#)

Department of Applied Physics, Chalmers University of Technology, Göteborg, Sweden

INTRODUCTION: The surface properties of materials in contact with biological systems play a key role in determining the outcome of biological-material interactions. Properties of particular relevance include physico-chemical, topographical, mechanical and bio-functionality. These properties should be considered on the same length scales as the biological entities that are interacting with the material, such as water, biomolecules, cells and organized tissue structures. There are a multitude of surface modification methods available to engineer custom designed interfaces. Many of these methods are not suitable for commercial applications, but can be useful in model studies to investigate the significance of specific aspects of a surface. The optimal surface will vary depending on the particular application, such as location of use for medical implants. More significantly, the optimal surface will vary with time, raising an interest in dynamic surfaces, as well as smart surfaces which react to a changing local biological environment.

METHODS: There are many techniques available to modify surfaces. Examples of methods include micro – and nanostructuring of surfaces via various lithographic techniques, imprinting and laser micromachining; shot peening, laser ablation, plasma spraying, gas plasma treatments, ion bombardment, chemical etching, chemical and physical vapor deposition, as well as coatings of polymers, ceramics, metals, molecular self-assembled coatings, as well as biopolymeric coatings of proteins, sugars, lipids, polyelectrolyte coatings and more. Several surface modification methods allowing the production of model test surfaces will be presented, and examples of biological interactions with surfaces made by these methods will also be shown.

RESULTS: Material surface characteristics on μm and nm length scales effect the structure and function of cells and proteins at biointerfaces in vitro. In addition, there are potential synergistic effects of chemical and structural properties on protein and cell behavior. The viscoelastic properties of biomaterial surfaces are being shown to influence cell behavior in vitro and tissue response in vivo. At times in vitro performance of

surface modifications predict an effect in vivo, however in other instances no effect of controlled surfaces are observed. Most likely a multitude of surface properties are acting in concert, and in time, as the biological situation at the interface is so dynamic and versatile.

DISCUSSION & CONCLUSIONS: During the past 20+ years, the importance of surface chemistry and topography for medical implants has been recognized and studied. As a result, several new techniques to modify surfaces in a controlled way have been developed or borrowed from other industries. Much research has been conducted to observe and subsequently control biological reactions at surfaces in vitro, and with much success. Unfortunately, the body is a complex environment, and many sophisticated surface modifications that are promising in vitro have shown little or no effect in vivo. A greater understanding of biological processes occurring at interfaces, and more complex in vitro models are required for significant advances in this area.

ACKNOWLEDGEMENTS: The Chemical Physics group at Chalmers, The Swedish, Biomaterials Consortium, the SSF Biocompatible Materials Program, the Swedish Research Council, and the Chalmers Bioscience Program.