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# Novel Engineered Nanocrystalline Ultra-hydrophilic Hard Ceramic Coatings for Attachment and Growth of Bone Marrow Stromal Cells

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## 1 Introduction

This paper addresses the adhesion, survival, and growth of a cloned bone marrow stromal cell line on the surfaces of engineered nanocrystalline ultrahydrophilic hard oxide ceramic films fabricated by ion beam assisted deposition. The cloned cell line is from C57Bl mice and is termed OMA-AD cells. OMA-AD is a spontaneously immortalized undifferentiated stromal cell population that resembles multipotential mesenchymal stromal cells (MMSC) that, in vitro, duplicate all of the characteristics of primary mesenchymal stem cells. The present study evaluates the interaction of cells on the surface of newly engineered nano-crystal films of stabilizer free cubic zirconia (with a hardness of 16 GPa), aluminum, titanium, tantalum, cerium oxides, and silver.

Many recent studies of the interaction of cells with engineered surface coatings have employed osteoblasts or osteoblast-like cell lines. In many situations of tissue repair the participating cell populations are more likely to be largely undifferentiated precursor cells, resembling mesenchymal stem cells (MSC), rather than differentiated osteoblasts. Consequently, there is merit in focusing on the evaluation of the interaction of these precursor cells, like the OMA-AD, with surface nanocrystalline coatings.

## 2 Materials and Methods

The engineered nano-crystal hard films with ultra-hydrophilic properties are produced by employing an ion beam assisted deposition (IBAD) technique. IBAD combines physical vapor deposition with concurrent ion beam bombardment (ionic hammer), in a high vacuum environment, to produce films (with 7 to 120 nm grain size) that are “stitched” to the artificial implant materials producing superior mechanical and adhesion properties. Grain size of nanocrystalline samples were determined by transmission electron microscopy (TEM) and surface roughness measured by atomic force microscopy (AFM).

## 3 Results

**Fig. 1** shows photomicrographs of OMA-AD growing on several nanocrystal surfaces. Because the silicon substrates are opaque to transmitted light, side illumination with a fiber-optic light source was used. OMA-AD cells can be seen growing on the nanostructurally stabilized cubic zirconia (free from any chemical stabilizer) (**Fig. 1A**), nanocrystalline tantalum oxide (**Fig. 1B**), and nanocrystalline titanium oxide (**Fig. 1C**). On the other hand, no cells can be seen growing on the nanocrystals of silver (**Fig. 1D**). All substrates were cultured for 12 days and the cells counted using a hemocytometer. Our results indicated that cubic zirconia supported the highest cell growth. Tantalum oxide and titanium oxide supported intermediate cell growth, and silver supported the lowest ce1l growth. Alamar Blue assay was performed to verify the above results as well as to determine the support of the OMA-AD cell growth on the nanocrystals. **Fig. 2** shows the growth of OMA-AD on cubic zirconia, aluminum oxide, titanium oxide (with anatase crystal structure), and silver. Again $ZrO_2$ supported the highest and the silver the lowest growth of OMA-AD cells.

## 4 Conclusion

Our studies have indicated that both chemistry and characteristics of nano-structured surface coatings

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can influence the adhesion, survival, and growth of MSC. Furthermore, these results suggest that appropriate modifications to the surfaces of orthopaedic artificial implants by IBAD can improve tissue integration and at the same time may inhibit the risk of infection. These postulates are now open to experimental verification in future studies.

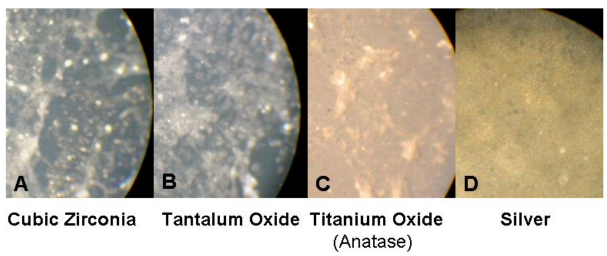


**Figure 1 :** Comparison of growth of cloned bone marrow stromal cells OMA-AD on different nanocrystalline coatings. (**A**) stabilizer free cubic zirconia with zero contact angle, total wettability to water, and roughness of about 13 nm; (**B**) nanocrystalline tantalum oxide with a contact angle of 20 degrees and roughness of about 6 nm; (**C**) nanocrystalline titanium oxide with zero contact angle, total wettability to water, and roughness of about 70 nm; and (**D**) elemental nanocrystalline silver with a contact angle of about 90 degrees and roughness of about 120 nm. (Magnification 79 X).

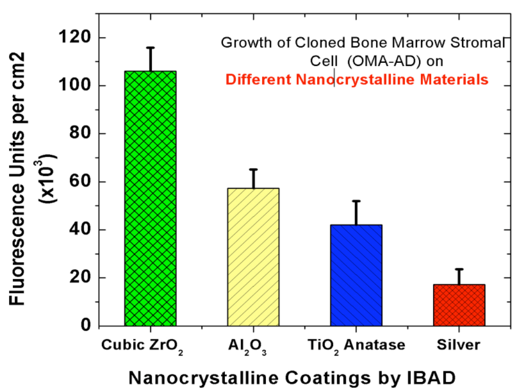


**Figure 2 :** Growth of cloned bone marrow stromal cells OMA-AD on different nanocrystalline coatings as determined by Alamar Blue assay.