European Cells and Materials Vol. 4. Suppl. 2, 2002 (pages 107-108) ISSN 1473-2262

SCULPTURED THIN FILMS AND GLANCING ANGLE DEPOSITION

K. Robbie, K. Kaminska, T. Brown, G. Beydaghyan

Department of Physics, Queen's University, Kingston, Ontario, Canada

INTRODUCTION: Recent progress in the ability to manufacture chemical and physical form on small scales has enabled the study of biological systems in new ways. Single cell or single molecule studies have replaced analysis of ensembles, with progress toward a consistent chemistry/biology/physics description of cellular behavior. Single molecule bonding studies with atomic force microscopes, self- and directed-assembly systems, and hybrid organic/inorganic systems are some examples of current work. At the nanometer scale, quantum mechanical effects blur the distinction between biological, chemical, and geometric effects. Understanding how biological systems interact with diverse physical form and chemistry is of prime research interest. Here we present a vacuum deposition technique for producing nanostructured surfaces with controlled three-dimensional form, and encourage discussion on suitable investigations of chemical, biological, and cellular interactions.

METHODS: When a material is heated in vacuum, it evaporates. The vapour traverses the vacuum and condenses as a thin film on any line-of-sight surfaces. Mirrors, eyeglasses, and cutting tools are coated this way with aluminum, magnesium fluoride, and titanium nitride layers, respectively. The films are usually dense, similar to the vapour material in bulk. Many simple organics can be vacuum coated, enabling the growing organic light emitting diode industry. Our technique, called Glancing Angle Deposition [l,2], tilts the vapour receiving substrate at a large angle relative to the vapour flux. Roughening during film growth, combined with atomic shadowing, promotes a porous structure with topological features typically near 100nm. Dynamically varying the geometry (tilting and rotating the substrate) controls the time-evolution of the growth, resulting in materials with designable nanostructured forms.

RESULTS: Although the range of structures that can be produced is limited, many geometries can be produced with this technique, including controlled chirality, porosity, chemistry, and anisotropy [2,3]. The two figures show tilted and plan view images of example sculptured thin films, obtained with field-emission scanning-electron microscopes,. In one experiment the thin film shown in *Figure 1* was saturated with simple nematic liquid crystal molecules. Influenced by the helical columns, the liquid crystal texture exhibited a chiral nematic phase.

Fig. 1: Chiral MgF_2 thin film on glass substrate. Helical pitch is approximately 300nm.

Fig.2: Plan view of an array of titanium (Ti) pillars 10-40nm in diameter.

DISCUSSION & CONCLUSIONS: Biological response to micro and nano structure is significant, and glancing angle deposition is a powerful technique to engineer myriad nanostructured forms.

REFERENCES: [1] K. Robbie and M.J. Brett, "Method of depositing shadow sculpted thin films", U.S. Patent No. 5,866,204. [2] K. Robbie, M.J. Brett, and D.J. Broer, "Chiral thin film/liquid crystal hybrid materials", Nature 399, 764-766, (1999). [3] I.J. Hodgkinson, Q.H. Wu, B. Knight, A. Lakhtakia, and K. Robbie, "Vacuum deposition of chiral sculptured thin films with high optical activity", Applied Optics 39 (4), 642-649, (2000).

ACKNOWLEDGEMENTS: A letter from Adam Curtis prompted my interest in this topic. His patient encouragement is appreciated.