Effect of Scale on Structure and Strength of Layered Nanostructures in Deformed Metals

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10:40 AM Invited
Nanoscale Colour Control: Protective Decorative Coatings: *Tomas Polcar*[1]; [1]Czech Technical University in Prague

In this talk we present a new design of decorative tungsten oxide coatings. The coatings were deposited with a graded refractive index by magnetron sputtering with pulsing the reactive gas. The controlled injection of the reactive gas can produced a concentration profile gradient from pure tungsten to tungsten trioxide, determining the final apparent colour of the coating. A dynamic sputtering model was built to simulate the growth of the coating during the reactive gas pulsing which was validated by direct measurement of the oxygen gradient. Finally, these results were used for an optical model allowing the optical properties of the deposited tungsten oxide layer to be described. This procedure allows the deposition of coatings with the desired colour by using the models to select the optimal oxygen pulse parameters. Proposed method can be easily applied to almost any metal/metal-oxide system to produce selected gradients of oxides or nitrides at nanoscale.

11:00 AM Break

Session 2: Nanoscale Multilayers II

Tuesday AM Room: Auditorium
October 1, 2013 Location: IMDEA Materials Institute

Session Chair: Reinhold Dauskardt, Stanford University

11:30 AM Keynote
Size Effects and Deformation Mechanisms in Metallic Multilayers: *Ruth Schwaiger*[1]; [1]Karlsruhe Institute of Technology (KIT)

The understanding of deformation of metallic multilayers has seen significant progress in the past decade. While nanoscale multilayers show great potential for high-strength applications, size-dependent deformation and predominant mechanisms are still under debate. Plastic deformation is governed by the constraint on dislocation motion but also strongly dependent on the interface structure between layers, which directly controls barrier strength and stability. Hindered dislocation motion inside small grains may make interfaces more active leading to interface-related deformation behaviors, e.g. grain rotation or grain boundary sliding typical of ultrafine grain sizes, possibly resulting in shear band formation. In this presentation, deformation behavior and size effects will be illustrated by means of two metallic multilayer systems with different combinations of microstructure length scale and interface structure (Cu/Au, Cu/Cr). The multilayers were investigated by indentation at different temperatures and insitu microcompression, both extremely useful methods for understanding mechanical behavior and deformation mechanisms of fine-grained structures.

12:10 PM Invited
Anisotropy of the Mechanical Response of Al/SiC Multilayers: *Javier Llorca*[1]; Jon Molina-Aldareguia[1]; Saeid Lotfian[1]; Carl Mayer[2]; Nikhilesh Chawla[2]; Amit Misra[3]; [1]IMDEA Materials Institute; [2]Arizona State University; [3]Los Alamos National Laboratory

Nanoscale multilayers are potential candidates for applications that require materials operating in extreme environments, like in thermo-solar and/or nuclear energy technologies. In the case of metal-ceramic multilayers, the combination of metallic and ceramic layers at the nanoscale has demonstrated a good combination of strength and toughness. However, these materials are inherently anisotropic due to the layered structure; however, the anisotropic response is not well understood because the strength has been traditionally measured by nanoindentation techniques. In this talk, we address this issue by comparing the mechanical behavior of Al/SiC multilayers as a function of loading direction using two different techniques: nanoindentation and micropillar compression. The former can be carried out without intensive sample preparation but analysis of the results is difficult due to the complex stress state imposed by the indenter. The latter requires the use of complex micromachining techniques but the results are easier to interpret.

12:30 PM Invited
Effect of Scale on Structure and Strength of Layered Nanostructures in Deformed Metals: *Niels Hansen*[1]; Xiaodan Zhang[1]; Xiaoxu Huang[1]; [1]Technical University of Denmark

Nanoscale multilayers in metals and alloys can be produced by various physical and chemical deposition techniques but they can also form by plastic deformation to large strain. The strengthening mechanisms are analyzed for two typical structures: (i) bulk structures with a layer thickness in the range 50 – 500 nm and (ii) surface structures with a layer thickness in the range 5 – 100 nm. The structural morphology and structural parameters are analyzed by various electron microscopy techniques. This microstructural analysis forms the basis for a discussion of strengthening mechanisms and strength-structure relationships at different length scale. Finally strength estimates are validated for bulk structures by tensile testing and for surface structures by hardness testing on the micro/nanometer scale.

12:50 PM Invited
Mechancial Behavior of Preferred Interfaces in Bulk Multilayer Nanocomposites Produced via Accumulative Roll Bonding: *Nathan Mara*[1]; John Carpenter[1]; William Mook[1]; Weizhong Han[1]; Shijian Zheng[1]; Thomas Nizolek[2]; Jian Wang[1]; Thomas Wynn[1]; Irene Beyerlein[1]; [1]Los Alamos National Laboratory; [2]University of California, Santa Barbara

In this presentation, we report on the plastic deformation mechanisms in Cu-Nb lamellar nanocomposites processed via Severe Plastic Deformation as a function of decreasing layer thickness. We utilize Accumulative Roll-Bonding (ARB) to process bulk Cu-Nb nanolamellar composites from 1 mm thick high-purity polycrystalline sheet down to layer thicknesses of 10 nm. This processing technique has the advantage of producing bulk quantities of nanocomposite material, and also exposes the interface and bulk constituents to large strains (1000's of percent). These extreme strains result in rolling textures, interfacial defect structures, and deformation mechanisms very different from those seen in nanolamellar composites grown via Physical Vapor Deposition methods. For instance, deformation twinning is observed in Cu in ARB material as opposed to PVD material. Mechanical properties and behavior will be discussed in terms of the effects of interfacial content on deformation processes at diminishing length scales, and defect/interface interactions at the

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References

[1] Hall–Petch and dislocation strengthening in graded nanostructured steel. Xiaodan Zhang, Niels Hansen, Yukui Gao, Xiaoxu Huang. Acta Materialia 2012; 60: 5933-5943.