



**Handbook of Metal Physics**

Series Editor: Prasanta Misra

**METALLIC  
MULTILAYERS AND  
THEIR APPLICATIONS**

Theory, Experiments, and Applications  
related to Thin Metallic Multilayers

**GAYANATH W. FERNANDO**

# Metallic Multilayers

**Nan Li**



## **Metallic Multilayers:**

**Metallic Multilayers** A. Chamberod, J. Hillairet, 1990-01-01 This book contains a series of lectures given in a Summer School held in Aussois France in September 1989 It offers a global perspective on the current state of the art in the rapidly emerging field of metallic multilayered structures

**Metallic Multilayers and their Applications** Gayanath Fernando, 2011-08-30 Thin Metallic multilayer films have become an important part in today's computer technology The giant magnetoresistance GMR effect which plays a central role here was discovered in the late 1980s This can be essentially described as the effect of a magnetic field on the electron transport leading to significant changes in the resistance Other aspects of multilayers systems such as stability growth confinement are also addressed Theoretical and experimental methods used in such work are described in some detail with special emphasis on density functional and spin density functional theories Magnetic anisotropy in thin films is also discussed while addressing unresolved issues and new results from exchange bias experiments Discusses the GMR effect What makes multilayers interesting and useful What are the latest discoveries in this field Simple insights into the physics behind multilayers Novel concepts at small length scales Theoretical and experimental background

International Symposium on Metallic Multilayers G Guntherodt, H Zabel, 2002

Proceedings of the Second International Symposium on Metallic Multilayers International Symposium on Metallic Multilayers (2, 1995, Cambridge), 1996

*Proceedings of the 4th International Symposium on Metallic Multilayers*, 2002

Magnetic Metallic Multilayers Randolph Quentin Hood, 1994

**Magnetic Metallic Multilayers**, 1994

Mechanical Properties and Radiation Tolerance of Metallic Multilayers Nan Li, 2011 High energy neutron and proton radiation can induce serious damage in structural metals including void swelling and embrittlement Hence the design of advanced metallic materials with significantly enhanced radiation tolerance is critical for the application of advanced nuclear energy systems The goals of this dissertation are to examine the fundamental physical mechanisms that determine the responses of certain metallic multilayers with ultra high density interface structures to plastic deformation and high fluence He ion irradiation conditions This dissertation focuses on the investigation of mechanical and radiation responses of Al Nb and Fe W multilayers Radiation induced microstructural evolution in Cu and Cu Mo multilayer films are briefly investigated for comparisons Al Nb multilayer films were synthesized by magnetron sputtering at room temperature The interface is of Kurdjumov Sachs orientation relationship In situ nanoindentation inside a transmission electron microscope TEM reveal that interfaces act as strong barriers for dislocation transmission and dislocations climb along the Al Nb interfaces at a much higher velocity than in bulk The evolution of microstructure and mechanical properties of Al Nb multilayers has been investigated after helium ion irradiations 100 keV He ions with a dose of  $6 \times 10^{16}$  cm<sup>2</sup> When layer thickness  $h$  is greater than 25 nm hardness barely changes whereas radiation hardening is more significant at smaller  $h$  This study shows that miscible fcc bcc interface with large positive heat of mixing is not stable during ion irradiation In parallel we investigate sputtered Fe W multilayers Film

hardness increases with decreasing  $h$  and approaches a maximum of 12.5 GPa when  $h = 1$  nm. After radiation hardening is observed in specimens when  $h = 5$  nm, however, hardness barely changes in irradiated Fe/W 1 nm specimens due to intermixing. In comparison, Cu/Mo 5 nm multilayers with immiscible interface has also been investigated after helium ion irradiations. Interfaces exhibit significantly higher helium solubility than bulk. He vacancy ratio affects the formation and distribution of He bubbles. The greater diameter of He bubbles in Cu than Mo originates from the ease of bubble growth in Cu via punching of interstitial loops. Finally, helium bubble migration and growth mechanisms were investigated in irradiated Cu 100 single crystal films via in situ heating inside a TEM. The activation energy for bubble growth is 0.02 eV at low temperature. At higher temperatures, the activation energy for bubble coalescence is 0.22 eV inside crystal and 0.34 eV close to surface. The migration mechanisms of helium bubbles involve continuous as well as Brownian movement.

Metallic Multi-layers and Epitaxy M. Hong, Donald Urban Gubser, Stuart A. Wolf, 1988 **Proceedings of the 5th International Symposium on Metallic Multilayers** Zbigniew Celinski, Thomas Joseph Silva, 2005 **Metallic Multilayers at the Nanoscale**, 1994. The development of multilayer structures has been driven by a wide range of commercial applications requiring enhanced material behaviors. Innovations in physical vapor deposition technologies in particular magnetron sputtering have enabled the synthesis of metallic based structures with nanoscaled layer dimensions as small as one to two monolayers. Parameters used in the deposition process are paramount to the formation of these small layer dimensions and the stability of the structure. Therefore, optimization of the desired material properties must be related to assessment of the actual microstructure. Characterization techniques as x-ray diffraction and high resolution microscopy are useful to reveal the interface and layer structure whether ordered or disordered, crystalline or amorphous, compositionally abrupt or graded and/or lattice strained. Techniques for the synthesis of metallic multilayers with subnanometric layers will be reviewed with applications based on enhancing material behaviors as reflectivity and magnetic anisotropy but with emphasis on experimental studies of mechanical properties.

*Metallic Multilayers* Nihon Kinzoku Gakkai, 1993 Proceedings of the 5th International Symposium on Metallic Multilayers (MML04) Zbigniew Celinski, Thomas Silva, 2005 Handbook of Nanomaterials Properties Bharat Bhushan, Dan Luo, Scott R. Schricker, Wolfgang Sigmund, Stefan Zauscher, 2014-03-13. Nanomaterials attract tremendous attention in recent researches. Although extensive research has been done in this field, it still lacks a comprehensive reference work that presents data on properties of different Nanomaterials. This Handbook of Nanomaterials Properties will be the first single reference work that brings together the various properties with wide breadth and scope.

**Proceedings of the 4th International Symposium on Metallic Multilayers (MML'01)** Gernot Güntherodt, 2002 Proceedings of the First International Symposium on Metallic Multilayers, 1-5 March 1993. International Symposium on Metallic Multilayers, S. Maekawa, Nihon-Kinzoku-Gakkai, 1993 Proceedings of the First International Symposium on Metallic Multilayers, 1993 *The Structural and Mechanical Properties of Metallic Multilayers*

John T. Hoekstra,1995      Selected Papers from the 7th International Symposium on Metallic Multilayers (MML2010), Berkeley, California, September 19 - 24, 2010 International Symposium on Metallic Multilayers, Peter Fischer, 2011  
Proceedings of the Third International Symposium on Metallic Multilayers (MML '98), 14-19 June 1998, Vancouver, Canada ,1999

## The Enigmatic Realm of **Metallic Multilayers**: Unleashing the Language is Inner Magic

In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing short of extraordinary. Within the captivating pages of **Metallic Multilayers** a literary masterpiece penned with a renowned author, readers attempt a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting impact on the hearts and minds of those that partake in its reading experience.

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