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ION PLATING: FUNDAMENTAL PROCESSING STUDIES AND
SYNTHESIS OF HIGH PERFORM (U) ILLINOIS UNIV AT URBANA
DEPT OF MATERIALS SCIENCE AND ENGINEER J M RIGSBEE

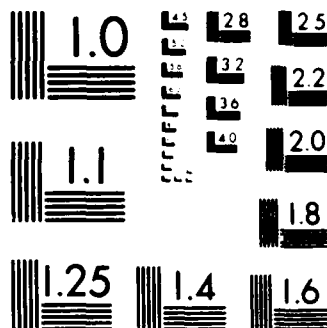
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Ion plating is a physical vapor deposition process which uses a plasma to modify the microstructure/microchemistry of thin film coatings. This research has directly shown that processing variables such as plasma energy/density; substrate temperature; deposition rate; and substrate surface chemistry directly effect the deposited film microstructure and chemistry. This processing technique allows mechanically strong/chemically graded interface layers to be produced between dissimilar materials. Film adhesion with this process is correspondingly excellent. This process was used to produce corrosion and wear resistant hard coatings. In a related portion of this program, a model was developed to explain experimental observations for thin film nucleation mechanisms. The analytical expressions developed were able to closely model film nucleation and showed that preferential nucleation at defect sites and the dissociation of small clusters are controlling factors for thin film nucleation based on an island growth model.			
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ION PLATING: FUNDAMENTAL PROCESSING STUDIES
AND SYNTHESIS OF HIGH PERFORMANCE COATINGS

FINAL REPORT

J. M. Rigsbee

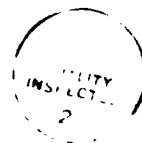
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FINAL REPORT

Statement of Problem

Ion plating is a physical vapor deposition process involving the deposition of a coating under continuous bombardment with low to medium energy ions. Coatings deposited by this process are recognized to have excellent physical properties and to be very useful under corrosion and wear conditions. In spite of the attractiveness of these coatings, little basic research has been done to understand how the many processing variables (e.g., ion energy and flux, substrate cleanliness and temperature, and deposition rate) affect the structure, chemistry and physical properties of these coatings. This was the major emphasis of this research program. This program also was concerned with obtaining a better understanding of thin film nucleation mechanisms. Primarily, the approach was to develop analytical expressions to model the effects of surface defects and small cluster dissociation on film nucleation via an island growth model. These expressions were compared with experimental data.

Summary of Results

This effort has yielded a much improved understanding of ion plated films and how processing variables influence the structure and chemistry of such films. Basically, the continuous ion bombardment during film growth promoted improved film density and adhesion. The film density is improved through conversion from a usual columnar growth mode (for no ion bombardment and low growth temperatures) to an equiaxed growth mode. Film adhesion is improved through the development of a chemically graded interface between the coating and substrate (this allows reduction of residual stress and thermal expansion coefficient difference effects). These studies mainly studied metal/metal elemental systems.

Other experimental efforts centered about production of titanium nitride and mixed oxide coatings through reactive ion plating. This work was done cooperatively with the U.S. Army Corps of Engineers Construction Engineering Research Laboratory. These coatings have uses ranging from corrosion to EMI/EMP. This interactive work is continuing.

The thin film nucleation modeling work was extremely productive. Analytical expressions were developed which significantly improved the ability to predict experimental results. This work showed that the dissociation of small clusters is a large contribution to the nucleation process, in direct conflict with other theoretical studies but in good agreement with available experimental data. Also, substrate surface defect density was shown to be critical and of rate controlling. Experimental efforts in this area are continuing.

Participating Scientific Personnel

J. M. Rigsbee, Principal Investigator

Y. W. Lee, completed Ph.D. degree in February, 1986
continued as Post Doc on this project and in
association with USA-CERL

J. C. Logas, completed M.S. degree in May, 1987

H. S. Savage, completed M.S. requirements, degree to be
awarded in Fall 1987

D. M. Leet, completed M. S. degree in December, 1984

Degrees: Master of Science -- 3

Doctor of Philosophy -- 1

Publications

- J. M. Rigsbee, "Surface Engineering by Laser and Physical Vapor Deposition Techniques," Journal of Metals 36(8), 31 (1984).
- J. M. Rigsbee, P. A. Scott, R. K. Knipe, C. P. Ju and V. F. Hock, "Structure, Chemistry and Adhesion of Ion-Plated Metal/Ceramic Interfaces," pp. 206-211 in Proc. of Intl. Conf. on Ion and Plasma Assisted Techniques, edited by H. Oechsner, CEP Consultants Ltd., Edinburgh, UK (1985).
- J. M. Rigsbee, V. F. Hock, L. D. Stephenson and P. A. Scott, "Novel Coatings by Plasma-Aided Physical Vapor Deposition," pp. 195-199 in New Materials and New Processes, Vol. 3, JEC Press, Cleveland, OH (1985).
- V. F. Hock and J. M. Rigsbee, "Enhanced Surface Coatings by Ion Plating," Army Research, Development and Acquisition, 26, No. 6, 25 (1985).
- V. F. Hock, L. D. Stephenson, J. H. Givens and J. M. Rigsbee, "Fabrication of Electrically Conductive Metal Oxide Coatings by Reactive Ion Plating," J. Vacuum Sci. & Tech., A3, 2661 (1985).
- J. M. Rigsbee, P. A. Scott, R. K. Knipe, C. P. Ju and V. F. Hock, "Ion Plated Metal/Ceramic Interfaces," Vacuum, 36, 71 (1986).
- J. M. Rigsbee, P. A. Scott, R. K. Knipe and V. P. Hock, "On the Modification of Metal/Ceramic Interfaces by Low Energy Ion/Atom Bombardment During Film Growth," p. 275, Proc. of NATO Advanced Studies Institute on Erosion and Growth of Solids Stimulated by Atom and Ion Beams, G. Kiriakidis, G. Carter and J. L. Whittun, Editors, Martinus Nijhoff Publishers, Boston, Series E. No. 112 (1986).
- L. D. Stephenson, V. F. Hock, J. M. Rigsbee, D. G. Teer and D. Arnell, "Microstructural Analysis of Electronically Conductive Ceramic Coatings Synthesized by Reactive Ion Plating and Sputter Deposition," p. 461, *ibid.*
- Y. W. Lee and J. M. Rigsbee, "The Effect of Dissociation Energies on Thin Film Nucleation Kinetics," Surface Science, 173, 30-48 (1986).
- Y. W. Lee and J. M. Rigsbee, "The Effect of Dimer Mobility on Thin Film Nucleation Kinetics," Surface Science, 173, 49-64 (1986).
- P. A. Scott and J. M. Rigsbee, "Studies of Ion Modified Metal/Ceramic Interfaces", p. 103, of The Applications of Ion Plating and Implantation to Materials, R. F. Hochman, Editor, ASM, Metals Park, 1986.
- L. D. Stephenson, J. M. Rigsbee and V. F. Hock, "Ion Plated Conductive Ceramic and Metal/Ceramic Composite Coatings," 1986 U.S. Army Science Conference, in press.
- P. A. Scott, R. K. Knipe, M. H. Shah and J. M. Rigsbee, "Studies of Ion Plated Metal/Ceramic Interfaces," in the Proc. of the 6th CIMTEC World Congress on High Tech Ceramics, Milan, Italy, June 1986.

M. C. Yoo, Y. W. Lee, J. H. Givens, M. Metzger, L. D. Stephenson, V. F. Hock, N. A. Sicilian, W. J. Crosiant and J. M. Rigsbee, "Ion Plated TiN: Studies of Adhesion and Corrosion Properties," IPAT 87, Bristol, May 1987, in press.

M. M. Shah, P. A. Scott and J. M. Rigsbee, "Structure-Chemistry-Properties of Metal/Ceramic Layered Composites Produced by Ion Plating," IPAT 87, Bristol, May 1987, in press.

L. D. Stephenson, A. Smith, J. M. Rigsbee and V. F. Hock, "Development of Space-Based Containerless Coating Processes," vol. 18, 18th Lunar and Planetary Institute Science Conference Proceedings, March 1987, Houston, in press.

C. H. Chen, C. P. Ju and J. M. Rigsbee, "Laser Surface Modification of Ductile Nodular Cast Iron: Part I. Microstructure; Part II. Wear Mechanisms," submitted for publication Materials Science and Technology.

C. P. Ju, C. H. Chen and J. M. Rigsbee, "Martensitic Transformation Processes in Austenitic Laser Processed Cast Iron," in preparation.

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