



E46949



DEPOSITION OF TITANIUM ALUMINIUM NITRIDE THIN FILM BY
REACTIVE UNBALANCED MAGNETRON SPUTTERING METHOD

MR. ADISORN BURANAWONG

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR

THE DEGREE OF DOCTOR OF PHILOSOPHY (PHYSICS)

FACULTY OF SCIENCE

KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

2010



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หน่วยกิต	48
ผู้เขียน	นายอดิศร บูรณวงศ์
อาจารย์ที่ปรึกษา	ศ.ดร.พิเชญชุ ลิ่มสุวรรณ
หลักสูตร	ปรัชญาดุษฎีบัณฑิต
สาขาวิชา	ฟิสิกส์
ภาควิชา	ฟิสิกส์
คณะ	วิทยาศาสตร์
พ.ศ.	2553

บทคัดย่อ

E 46949

ฟิล์มบาง ไททาเนียม อลูมิเนียม ในไตรค์ ที่มีโครงสร้างระดับนาโน จะถูกเคลือบลงบนวัสดุรองรับที่ไม่ถูกให้ความร้อนต่างชนิดกัน เช่น ซิลิโคน กระจก และ Cu-grid ด้วยวิธีรีแอคตีฟ อันนาลานซ์ แมกนีตอ่อน สปัตเตอริ่ง โดยใช้ไททาเนียมและอลูมิเนียมเป็นเป้าสารเคลือบแบบโคลสปัตเตอริ่ง ทำการเคลือบฟิล์มบาง โดยกำหนดให้กระแสสปัตเตอริ่งของเป้าอลูมิเนียมคงที่เท่ากับ 0.6 A กระแสสปัตเตอริ่งของเป้าไททาเนียมเป็น 0.6, 0.7, 0.8, 1.0 และ 1.2 A แต่ละกระแสสปัตเตอริ่งจะใช้เวลาในการเคลือบเป็น 15, 30, 45 และ 60 นาที ตามลำดับ ฟิล์มบางที่เคลือบได้จะนำไปศึกษาและวิเคราะห์ โครงสร้างผลลัพธ์ทั้งโครงสร้างจุลภาคด้วย X-ray diffraction (XRD) และ transmission electron microscopy (TEM) ลักษณะพื้นผิวและความหนาศักยภาพด้วย atomic force microscopy (AFM) ภาคตัดขวางวิเคราะห์ด้วย field emission scanning electron microscopy (FE-SEM) ผลการศึกษาพบว่าโครงสร้างผลลัพธ์ ลักษณะพื้นผิวและ โครงสร้างจุลภาคของฟิล์มบางเปลี่ยนแปลงไปตามเงื่อนไขในการเคลือบ จากเทคนิค XRD พบรูปแบบการเลี้ยวเบนแบบ polycrystal ที่ระนาบ (112) (004) และ (153) ตรงกับโครงสร้างผลึกนาโนรูปของอลูมิเนียม ไททาเนียม ในไตรค์ ($AlTi_3N$) crystallite size ที่คำนวณจาก Scherrer's formula ขึ้นอยู่กับเงื่อนไขการเคลือบ เช่นกัน ทั้งนี้เทคนิค TEM ยังยืนยันโครงสร้าง $AlTi_3N$ ที่ได้ โดยแสดงว่ามีปริมาณของอลูมิเนียมสูง ความหมายผิวและความหนาเฉลี่ยจะขึ้นอยู่กับกระแสที่ให้กับเป้าไททาเนียมและเวลาในการเคลือบ สำหรับภาคตัดขวางที่วิเคราะห์ด้วยเทคนิค FE-SEM พบรูปแบบการเลี้ยวเบนแบบ colloid ที่ขัดเรียงตัวแบบแน่น

คำสำคัญ: ไททาเนียม อลูมิเนียม ในไตรค์/ อันนาลานซ์ แมกนีตอ่อนสปัตเตอริ่ง/ เป้าสารเคลือบแบบโคลสปัตเตอริ่ง

Dissertation Title	Deposition of Titanium Aluminium Nitride Thin Film by Reactive Unbalanced Magnetron Sputtering Method
Dissertation Credits	48
Candidate	Mr. Adisorn Buranawong
Dissertation Advisor	Prof. Dr. Pichet Limsuwan
Program	Doctor of Philosophy
Field of Study	Physics
Department	Physics
Faculty	Science
B.E.	2553

Abstract

E46949

In this research, nanostructure titanium aluminium nitride thin films were deposited on three different unheated substrates, Si, glass, Cu-grid by reactive unbalanced magnetron sputtering. Ti and Al were used as co-sputtering targets. Al sputtering current was kept constant at 0.6 A whereas Ti sputtering current was set at different 0.6, 0.7, 0.8, 1.0, 1.2 A. For each Ti current, the film was deposited at different time of 15, 30 45 and 60 min, respectively. The deposited films were then characterized and analyzed by X-Ray Diffraction (XRD), Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). The results indicated that the modification of crystal structure, surface morphology and microstructure were depended on deposition parameters. The XRD patterns show polycrystalline structure with preferred orientations in (112), (004) and (153) planes which agree with standard structure of aluminium titanium nitride ($AlTi_3N$) films. The crystal size calculated from Scherrer's formula was depended on deposition parameters. In addition, the structure of $AlTi_3N$ was also confirmed by TEM. These results show that the films compose of high Al content. The root mean square surface roughness and the average thicknesses were strongly influenced by I_{Ti} and deposition times. Cross section analysis by SEM showed dense and compact columnar morphology.

Keywords: Titanium Aluminium Nitride/ Unbalanced Magnetron Sputtering/ Co-sputtering Targets

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to Professor Dr. Pichet Limsuwan for his support and vast knowledge of guidance including instrument supports in this thesis work and, throughout the course of this collaborative research. His expertise and insightful advice were essential to the successful completion of this work. My special thanks to Dr.Somyod Denchitcharoen, Dr.Panita Chinvetkitvanich and Associate Professor Dr.Surasing Chaiyakun for corporative encouragements and reviews of the thesis manuscript.

I would like to thank all the colleagues that have made the completion of this thesis work possible. Thanks to Dr.Artorn Pokaipisit for their academic and technical support on analytical methods and many research data. Special thanks to Associate Professor Dr.Surasing Chaiyakun and Assistance Professor Nirun Witit-anun for the fruitful discussions and enthusiastic collaborations during this work, and has been deeply involved in many aspects of this research. My appreciation is to Mr. Panya Saekhow and Mr. Tanapong Chaturapat for their assistance in sputtering machine at Vacuum and Thin film Technology Research Laboratory, Department of Physic, Faculty of Science, Burapha University and many research data.

Grateful appreciation is directed to Assistance Professor Dr. Patama Visuttipitukul, Metallurgical Engineering, Faculty of engineering, Chulalongkorn University, for technical supports in XRD equipments. Thanks to Mr. Sirawat Peanpatanasin and Mr. Boolaer Ngotawornchai, Scientific and Technology Research Equipment Centre, Chulalongkorn University, for their assistance in technical support of AFM and TEM equipments.

My gratitude is dedicated to all my family for giving me love and inspiration, especially my mother and my father. I am also very pleased to thank all my friends in KMUTT Laser Lab and many others, who have accompanied me along the journey.

Finally, I am greatly appreciate all the authors of research papers that this work referenced and deficient to reference and my gratitude is dedicated to all my teachers for this thesis.

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LIST OF SYMBOLS

a	lattice constant
B	magnetic field
d_{s-t}	target-substrate distant
D	crystallite size
\bar{e}	electron
E	electric field
E_b	optical band gap energy
hkl	Miller indices
K	Kelvin
mtorr	milli-torr
N	magnetic north pole
R_{rms}	root mean square roughness
S	magnetic south pole
T	transmittance
$AlTi_3N$	aluminium titanium nitride
T/T_m	deposited temperature per melting temperature
z_i	height value of each point
\bar{z}	average height of the scanned area
β	width at the half height of the peak
θ	diffraction angle
α	absorption coefficient wavelength

ABBREVIATIONS

2D	two-dimensional
3D	three-dimensional
AFM	atomic force microscope
CDS	cathode dark space
DC	direct current
RF	radio frequency
FCC	face centered cubic
FWHM	full width at half maximum
JCPDS	joint committee on powder diffraction standard
NG	negative growth
SEM	scanning electron microscopy
TEM	transmission electron microscopy
XRD	X-ray diffraction