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

MR. ADISORN BURANAWONG

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT  
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2010

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บทคัดย่อ

**E46949**

ฟิล์มบางไททาเนียม อลูมิเนียม ไนไตรด์ ที่มีโครงสร้างระดับนาโน จะถูกเคลือบลงบนวัสดุรองรับที่ไม่ถูกให้ความร้อนต่างชนิดกัน เช่น ซิลิกอน กระชก และCu-grid ด้วยวิธีรีแอคทีฟ อันบาลานซ์แมกนีตรอน สเปดเตอริง โดยใช้ไททาเนียมและอลูมิเนียมเป็นเป้าสารเคลือบแบบโคสเปดเตอริง ทำการเคลือบฟิล์มบางโดยกำหนดให้กระแสสเปดเตอริงของเป้าอลูมิเนียมคงที่เท่ากับ 0.6 A กระแสสเปดเตอริงของเป้าไททาเนียมเป็น 0.6, 0.7, 0.8, 1.0 และ 1.2 A แต่ละกระแสสเปดเตอริงจะใช้เวลาในการเคลือบเป็น 15, 30, 45 และ 60 นาที ตามลำดับ ฟิล์มบางที่เคลือบได้จะนำไปศึกษาและวิเคราะห์โครงสร้างผลึกรวมทั้งโครงสร้างจุลภาคด้วย X-ray diffraction (XRD) และ transmission electron microscopy (TEM) ลักษณะพื้นผิวและความหนาศึกษาด้วย atomic force microscopy (AFM) ภาควัดขวางวิเคราะห์ด้วย field emission scanning electron microscopy (FE-SEM) ผลการศึกษาพบว่าโครงสร้างผลึก ลักษณะพื้นผิวและ โครงสร้างจุลภาคของฟิล์มบางเปลี่ยนแปลงไปตามเงื่อนไขในการเคลือบ จากเทคนิค XRD พบรูปแบบการเลี้ยวเบนแบบ polycrystal ที่ระนาบ (112) (004) และ (153) ตรงกับโครงสร้างผลึกมาตรฐานของอลูมิเนียม ไททาเนียม ไนไตรด์ ( $\text{AlTi}_3\text{N}$ ) crystallite size ที่คำนวณจาก Scherrer's formular ขึ้นอยู่กับเงื่อนไขการเคลือบเช่นกัน ทั้งนี้เทคนิค TEM ยังยืนยันโครงสร้าง  $\text{AlTi}_3\text{N}$  ที่ได้ โดยแสดงว่ามีปริมาณของอลูมิเนียมสูง ความหยาบผิวและความหนาเฉลี่ยจะขึ้นอยู่กับกระแสที่ให้กับเป้าไททาเนียมและเวลาในการเคลือบ สำหรับภาควัดขวางที่วิเคราะห์ด้วยเทคนิค FE-SEM พบว่าจะมีลักษณะแน่นและเป็นแบบคอลัมน์นาที่จัดเรียงตัวแบบแน่น

คำสำคัญ: ไททาเนียม อลูมิเนียม ไนไตรด์/ อันบาลานซ์แมกนีตรอนสเปดเตอริง/ เป้าสารเคลือบแบบโคสเปดเตอริง

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## Abstract

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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 ( $\text{AlTi}_3\text{N}$ ) films. The crystal size calculated from Scherrer's formula was depended on deposition parameters. In addition, the structure of  $\text{AlTi}_3\text{N}$  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  $I_{\text{Ti}}$  and deposition times. Cross section analysis by SEM showed dense and compact columnar morphology.

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

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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
$\beta$	width at the half height of the peak
$\theta$	diffraction angle
$\alpha$	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