



679 / -  
2006

(TiN, AIN)

SS 304

·  
·

:

- 
- 
- 
-

\_\_\_\_\_

	4	.1
	5	.2
6		.3
6.....		1.3
8.....		2.3
8.....		1.2.3
8.....		2.2.3
10.....		3.2.3
10.....		4.2.3
	10	.4
10.....		1.4
12.....		2.4
13.....		3.4
	23	.5
	23	.6
	24	.7

2.8 kJ (plasma focus device)

TiN

AlN

SS304

0.5-0.75

(shots)

(substrate)

mbar

. %50

. 1-2 $\mu$ m

**Abstract:**

**Deposition of AlN and TiN Thin Films on Substrates of Stainless Steel SS304 Using Plasma Focus Device**

Dr. Sharif Al-Hawat

Dr. Mohamad Soukieh

Eng. Methgal Abou Kharoub

Mr. Walid Al- Sadat

A plasma focus device with energy of 2.8 kJ was used to deposit thin films of aluminium nitride AlN and titanium nitride TiN on Sstainless Steel 304 substrate, in order to improve its surface properties. The deposition process was carried out using various number of nitrogen plasma shots at pressures 0.5-0.75 mbar and at different sample's distances from the anode. The plasma diagnostics was achieved to determine the temperature and plasma density using the voltage and current signals recorded by voltage divider and Rogovskii coil. The surface hardness of SS-304 was increased by about 50% after plasma coating and the thickness of the coated layers was about 1-2 $\mu$ m. This study shows that the hardness is increased with increasing the number of shots and decreased with the distance from the anode. The coated layers were characterized and a qualitative understanding of the deposition process was given.



[6] 3.3 kJ Mather  
( - ) [7] TiC [4] TiN  
" ICTP Mather  
He, Ne, N<sub>2</sub>, Ar 2.8 kJ "  
[8- .10]

2.8 kJ

SS304

0.5-0.75 mbar

)  
(

**.3**

**1.3**

Mather

1

.ICTP/PFF -

( )

.15 kV

$2 \times 10^{-3}$  mbar

$.4 \times 10^{-4}$  mbar/min

0.25 mbar

4.5cm × 4.5cm × 0.5 cm

25 cm

5 cm × 5 cm

(shutter)

.1

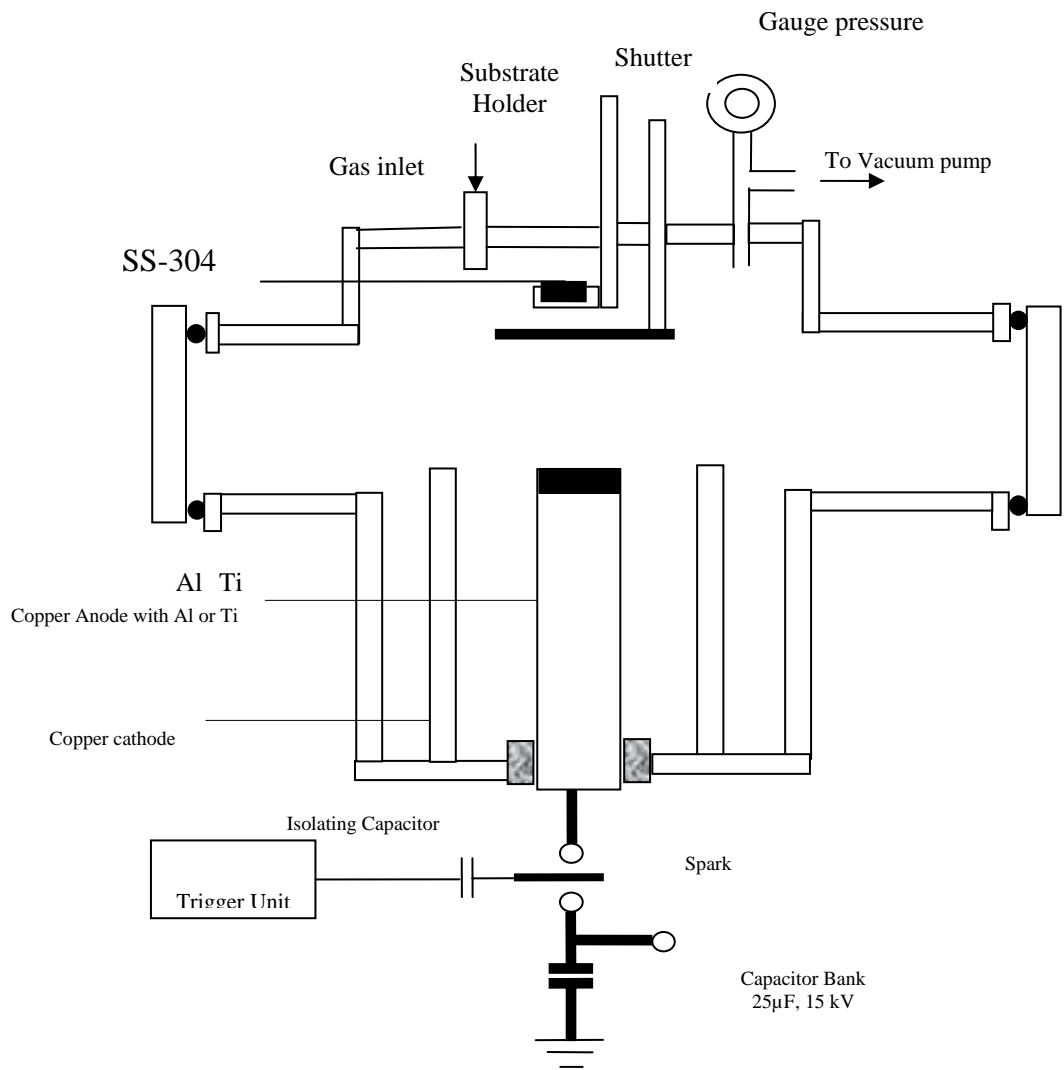
15 kV

0.75 mbar

0.5 mbar

Tektronics TDS 520C Digital Storage

Oscilloscope



1

2.3

1.2.3

20mm×20mm×5mm SS304

800 °C

$10^{-2}$  mbar

2.2.3



304

1

0.5 mbar

0.75 mbar

15 kV

.( 1-20 )

( 2-7 cm )

:

1

1

15 kV			
	mbar	cm	
20	0.57	2	1
20	0.50	3	2
20	0.48	4	3
15	0.47	3	4
10	0.48	3	5
10	0.48	2	6

2

2

15 kV			
	mbar	cm	
10	0.75	3	1
10	=	7	2

5	=	3	3
1	=	3	4
1	=	2	5
1	=	4	6
1	=	5	7

### 3.2.3

)EDX

.100X

Leica

(

. X-Ray Diffraction (XRD)

### 4.2.3

(Vickers)

. 10,25, 50,100,200,500,1000 g :

hardness tester (AFFRI)

.4

1.4

)

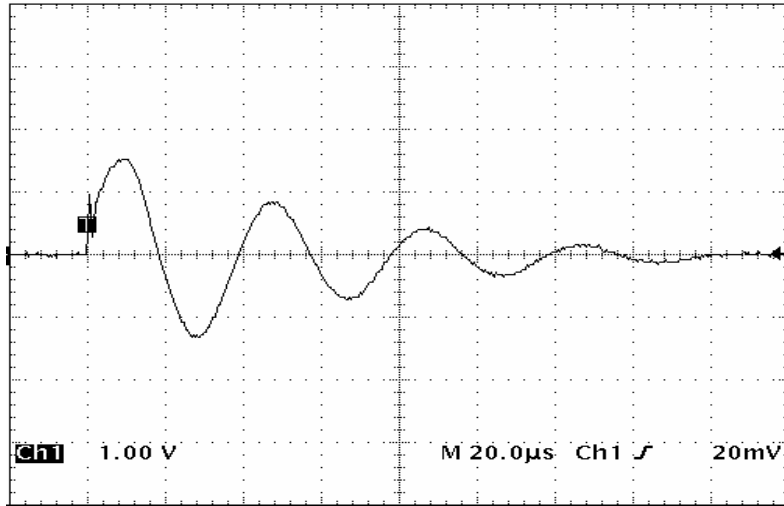
25μF, 15 kV

.0.5-5mbar

( 10

4 mbar

. 2



. 4 mbar

2

36.28 kA/V

54.4 kA

2

. [8]

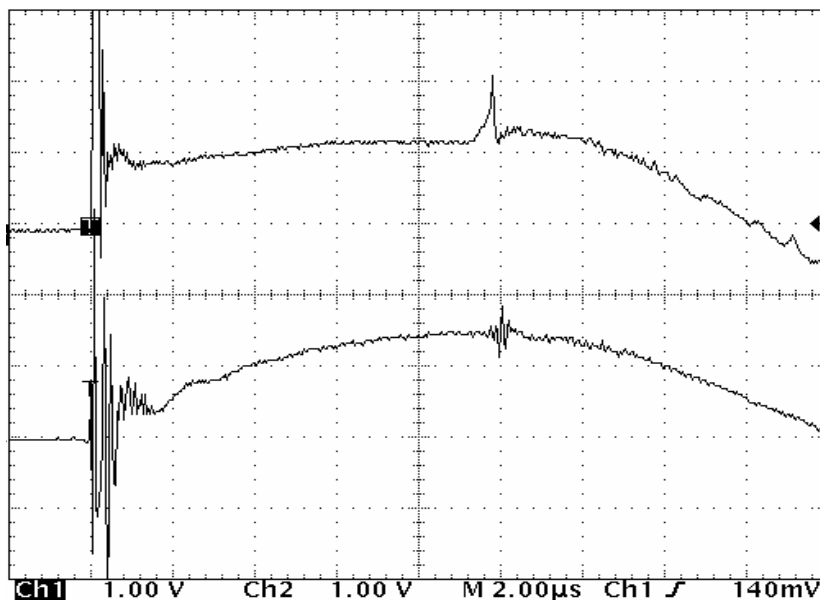
3

$9.64 \times 10^{22} \text{ m}^{-3}$   $2.86 \times 10^4 \text{ K}$  [11]

0.47 mbar

3

. 15 kV



0.47 mbar

( ) ( )

3

15 kV

2.4

EDX

3

3

%2.5

( )

EDX

3

Fe	Al	Cr	Ni	Mn	S	Si	%
	-	18-20	8-10	2.0	0.03	1.0	
	0.27	19.66	8.79	1.90	0.02	0.81	
	2.56	19.26	8.90	1.90	0.02	0.91	

)

XRD

(

(BCC) $\alpha$ -Fe (FCC) $\gamma$ -Fe:

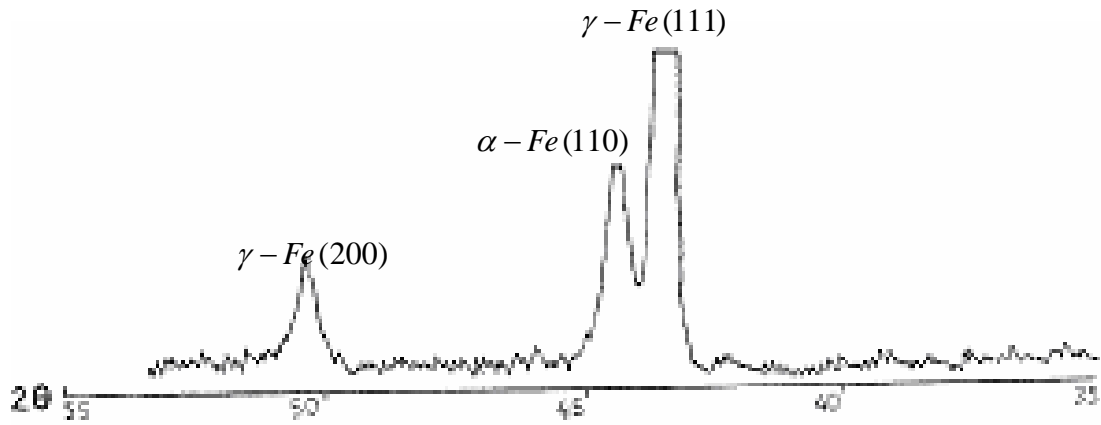
1  $\mu$ m

. 4

XRD

.( )

XRD



4

3.4

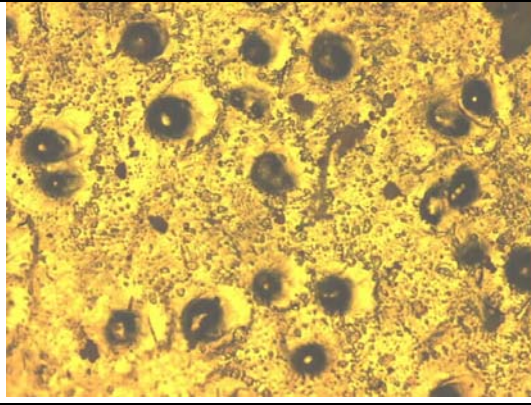
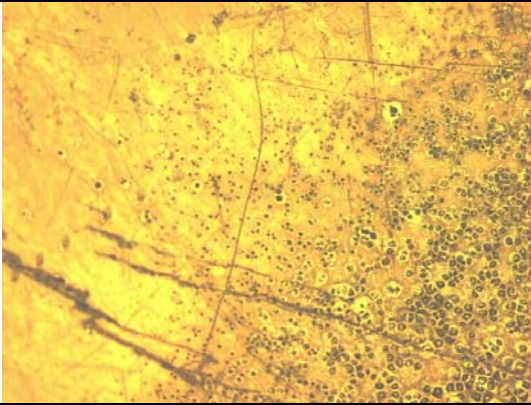
5

. 195 kg/mm<sup>2</sup>

304	304
5b	5a

11-6

20



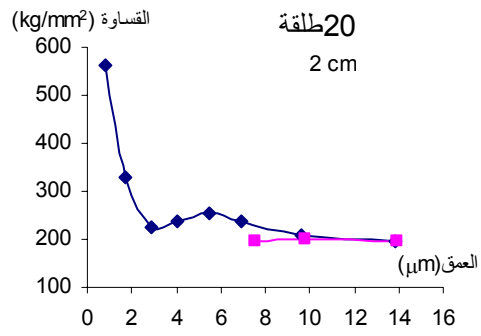
( )

6b

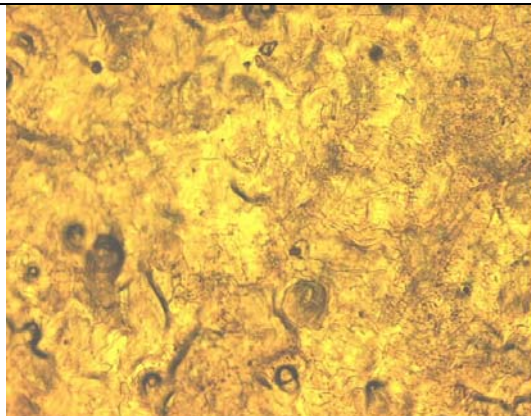
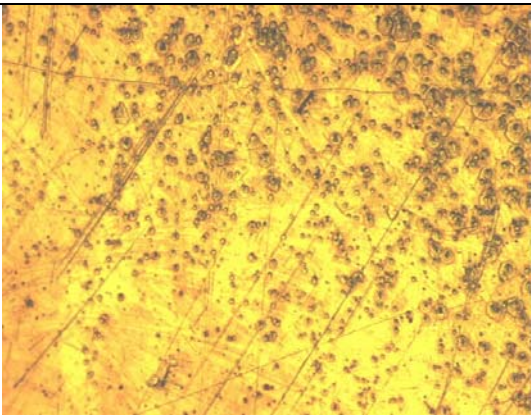
( )

6a

2 cm



6c



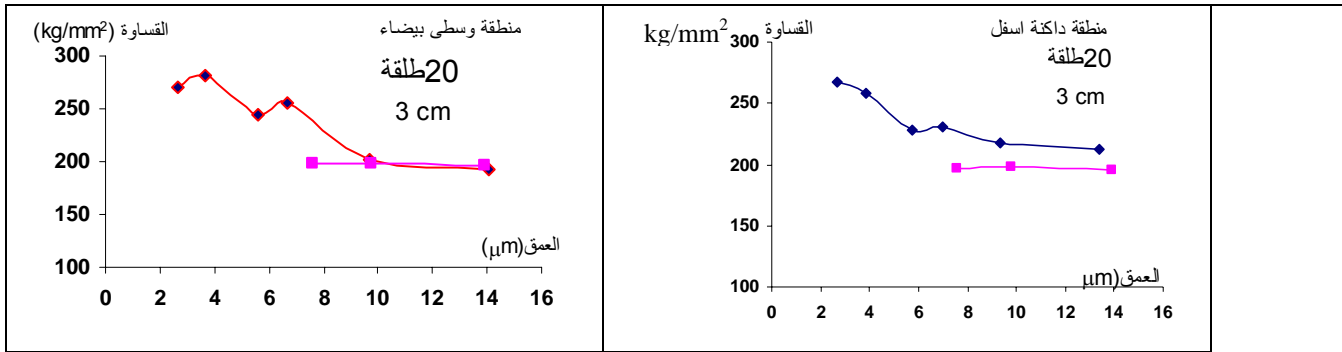
( )

7b

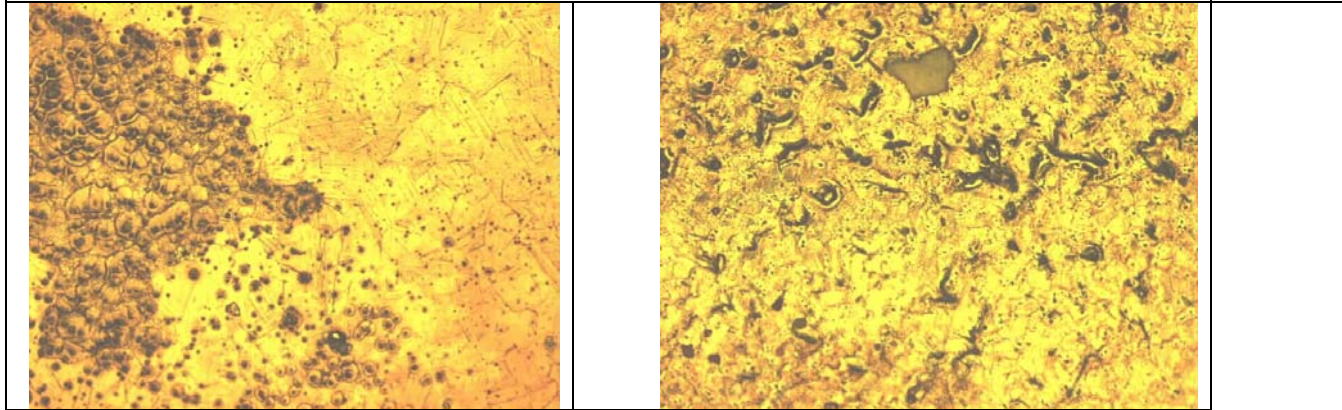
( )

7a

3 cm



7c



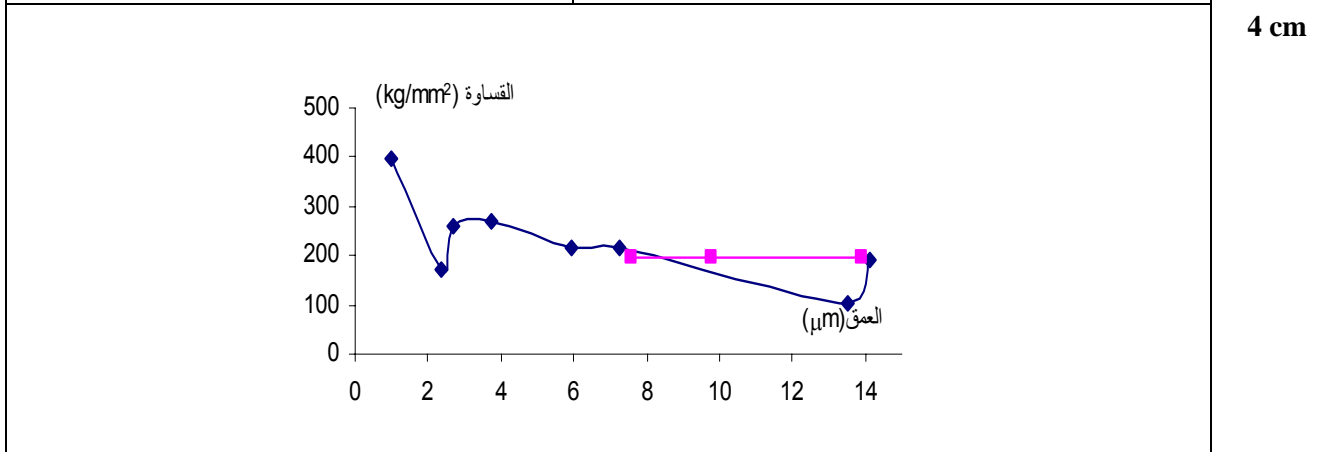
( )

8b

( )

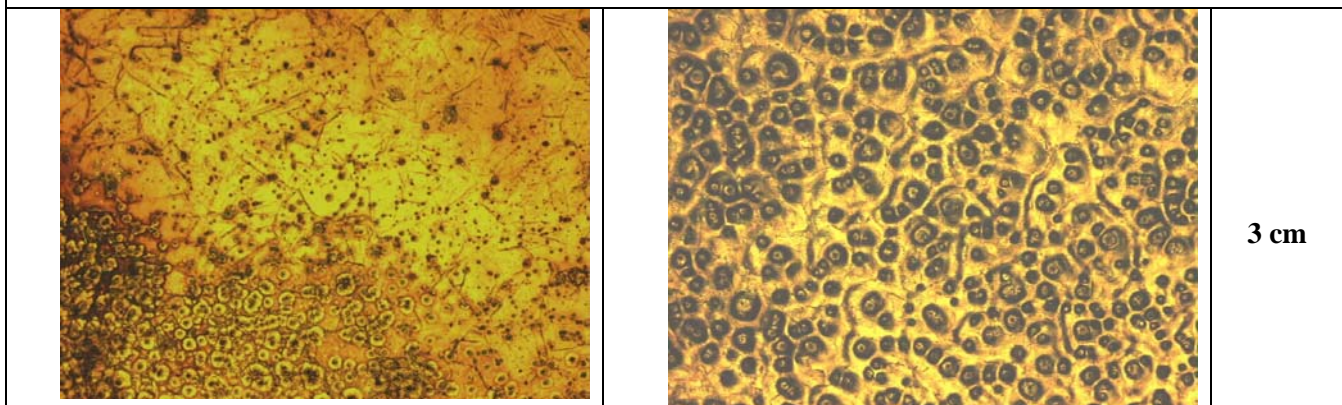
8a

4 cm



8c

15

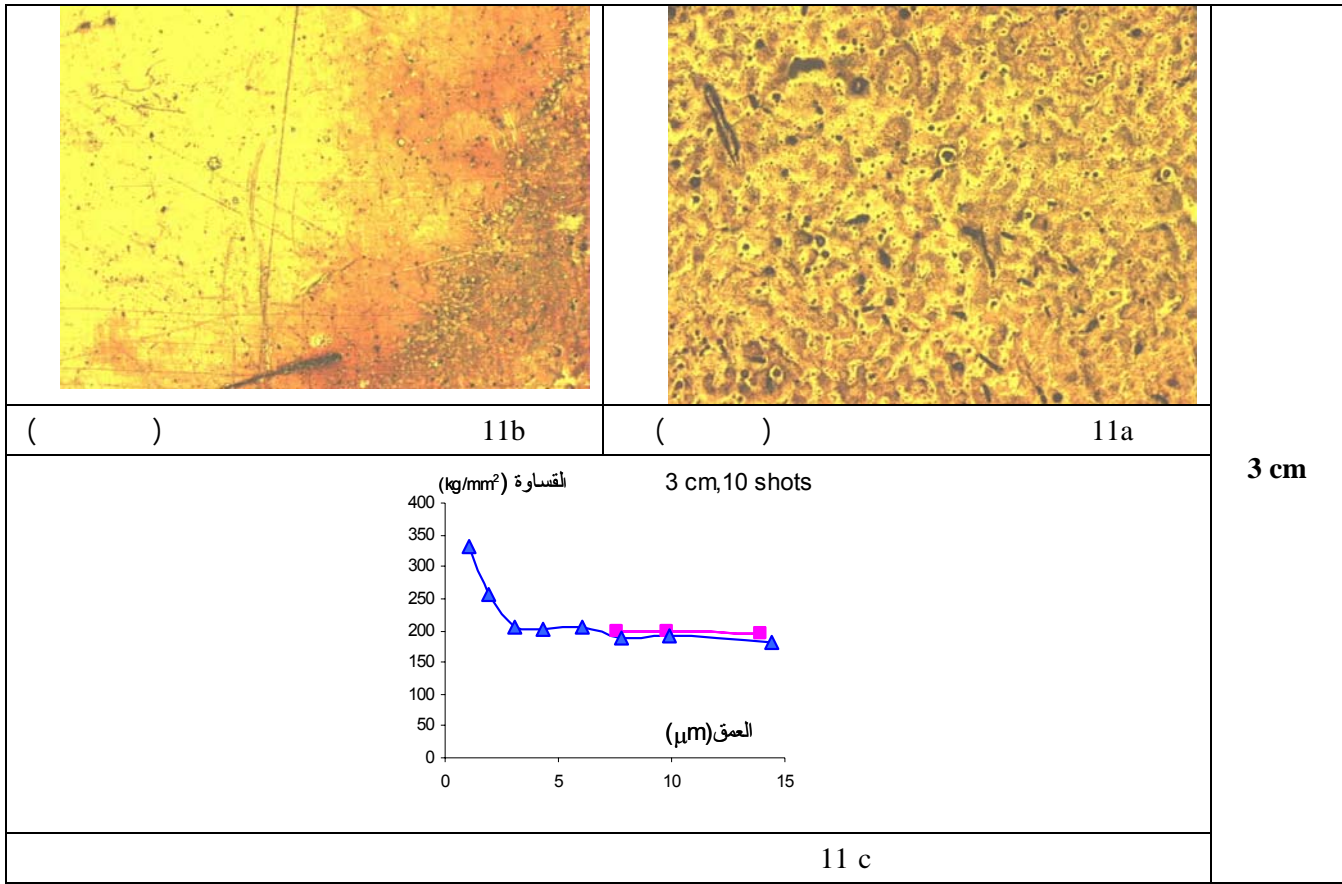


3 cm

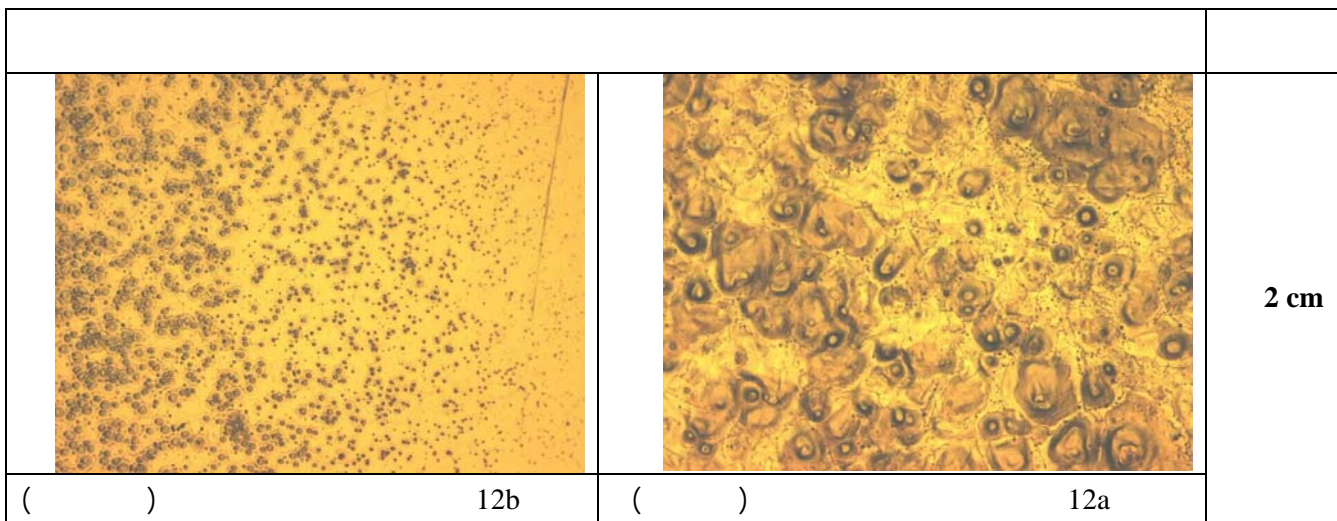


( )	9b	( )	9a
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>القساوة (kg/mm<sup>2</sup>)</p> <p>15 طلقة 3cm</p> </div> <div style="text-align: center;"> <p>العمق (μm)</p> </div> </div>			
9c			
<b>10</b>			
		<b>2 cm</b>	
( )	10b	( )	10a
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>القساوة kg/mm<sup>2</sup></p> <p>10 طلقة 2cm</p> </div> <div style="text-align: center;"> <p>العمق (μm)</p> </div> </div>			
10c			

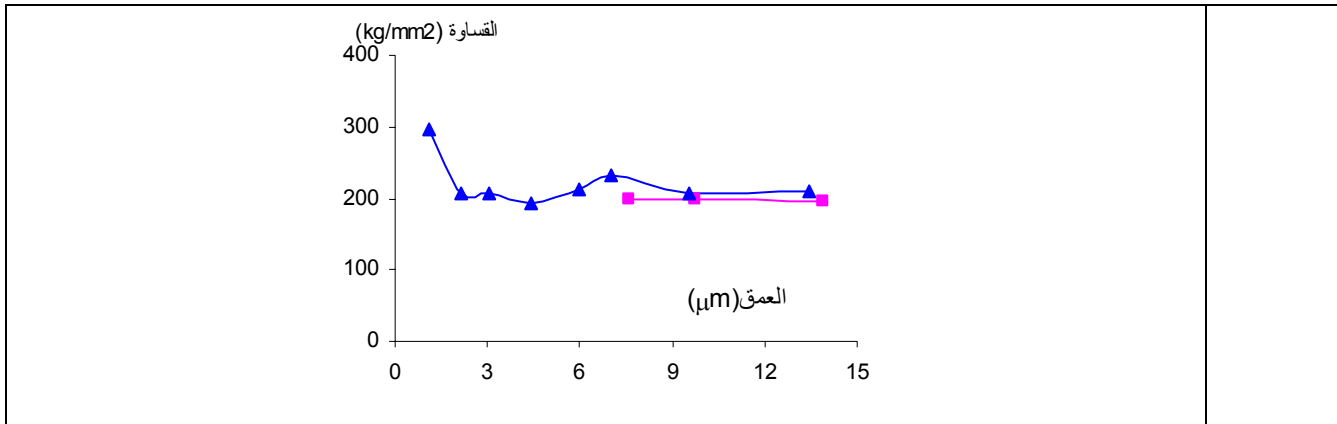




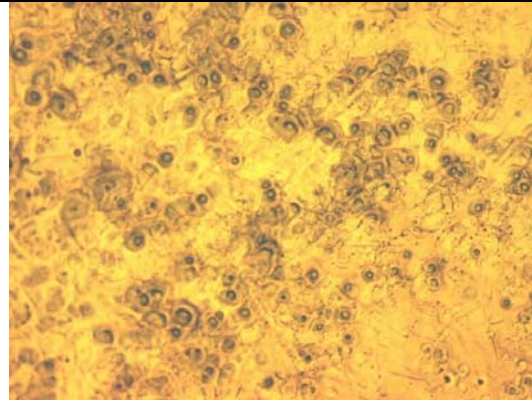
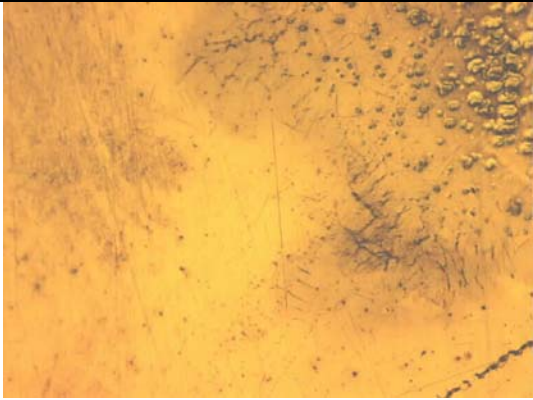
18 - 12



<p>القساوة (kg/mm<sup>2</sup>) طلقة واحدة 2cm</p> <p>العمق (μm)</p>	<p>القساوة (kg/mm<sup>2</sup>) طلقة واحدة</p> <p>العمق (μm)</p>		
<p>12d ( )</p>	<p>12c ( )</p>		
		<p>3 cm</p>	
<p>القساوة (kg/mm<sup>2</sup>) طلقة واحدة 3cm</p> <p>العمق (μm)</p>	<p>القساوة (kg/mm<sup>2</sup>) طلقة واحدة 3cm</p> <p>العمق (μm)</p>		
<p>( ) 13b</p>	<p>( ) 13a</p>		<p>13 c ( ) ( )</p>
		<p>4 cm</p>	
<p>( ) 14b</p>	<p>( ) 14a</p>		



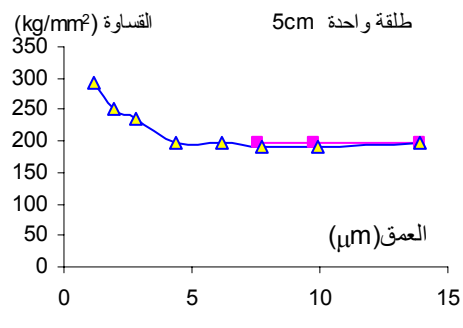
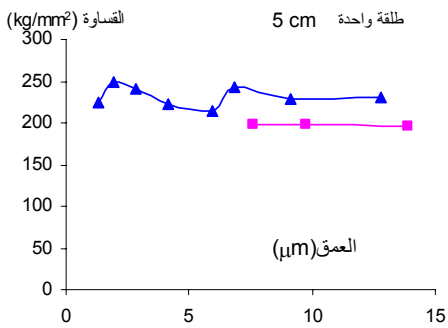
14c



( ) 15b

( ) 15a

5 cm



15d

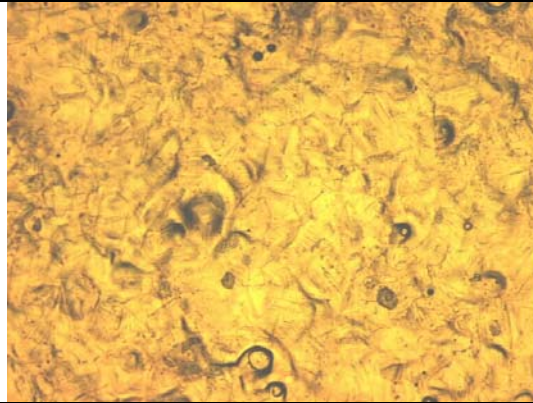
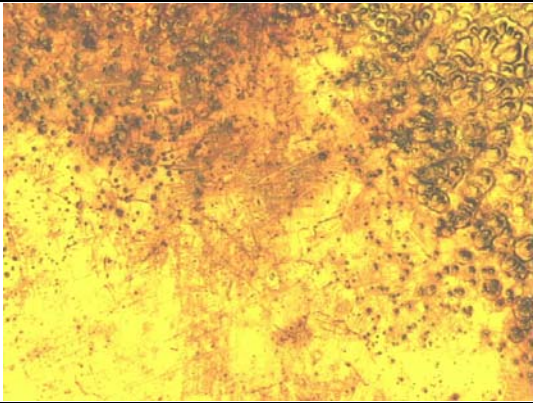
15 c

( )

( )



5



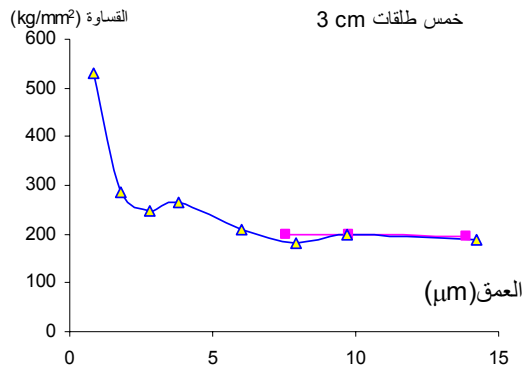
( )

16b

( )

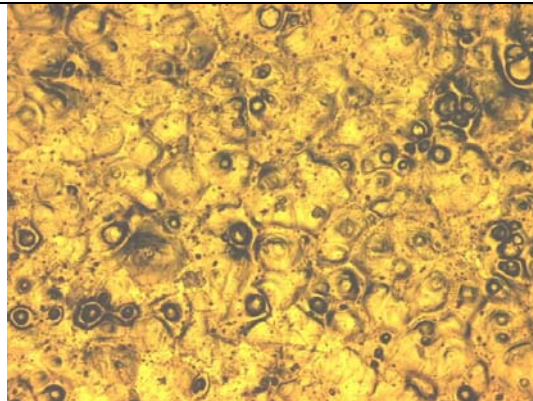
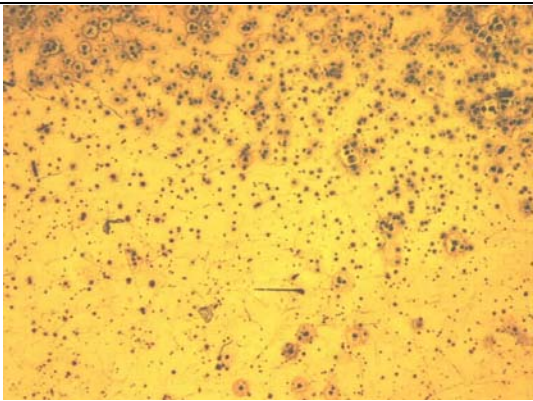
16a

3 cm



16c

10



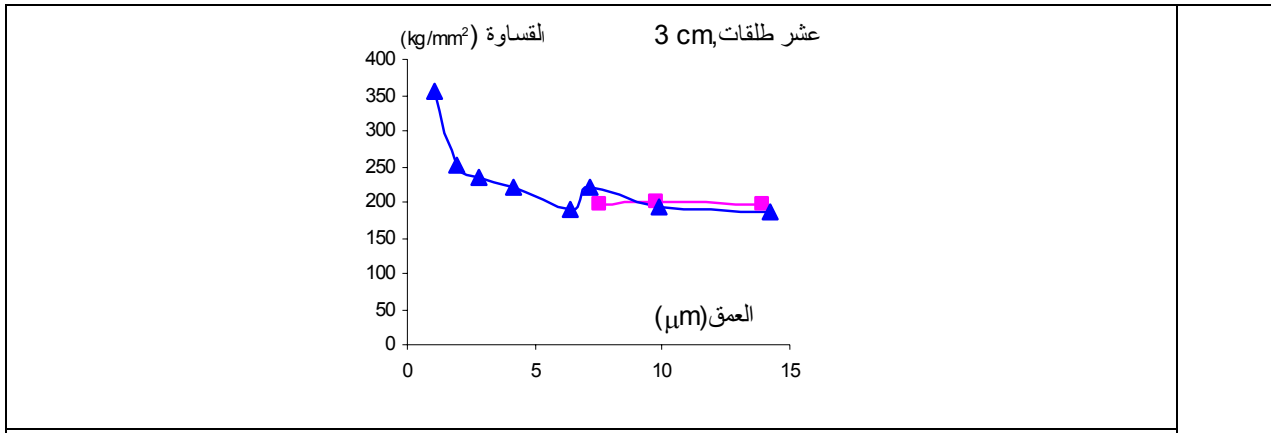
( )

17b

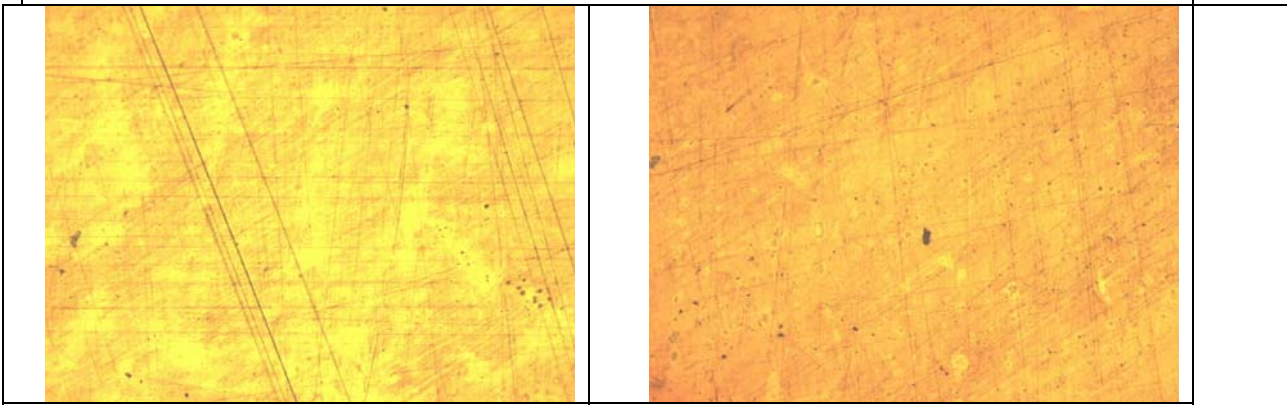
( )

17a

3 cm



17c



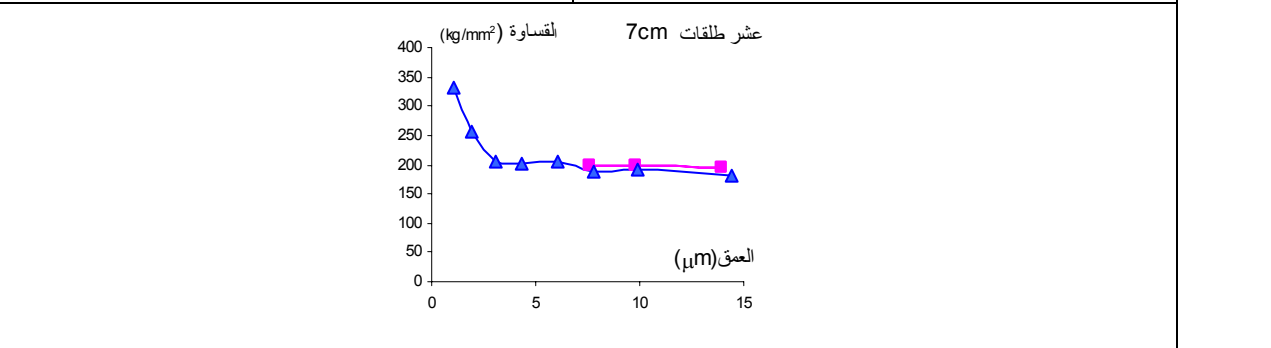
( )

18b

( )

18a

7 cm



18c

.1-2μm

%50

10-12 mm

.20mmX20mm

(6-18)

$10^6$  :  
 .8mm : -1  
 1-2  $\mu\text{m}$  )  
 .(1-2  $\mu\text{m}$   $\text{cm}^2 \setminus$   
 0.1- : -2  
 0.5 $\mu\text{m}$   
 .(7 )  $\text{cm}^2 \setminus 10^8$

( $\approx 10^{25} - 10^{26} \text{m}^{-3}$ )

( ) ( )  
 ( )  
 ( )  
 (Ti TiN ) Al AlN  
 ( )  
 ( )  
 ( )  
 AlN ( )  
 TiN

.5

2.8 kJ

304

TiN

AlN

0.5-0.75 mbar

( )

%50

.1-2μm

.6

- [1] I. Novikov, Theory of Heat Treatment of Metals, English translation, Mir Publishers, (1974) p. 402-404.
- [2] Natesan,-K. Development of aluminum nitride insulator coatings for fusion reactor applications (Argonne National Lab., IL (United States). Energy Technology Div.), (1995)
- [3] Ruby Gupta, Rachna Garg and M.P. Srivastava, ‘Titanium Carbide Film Deposition Using Dense Plasma Focus, Proceedings of the Regional Conference on Plasma Research in 21 st century, Bangkok, Thailand, May 7-12, 2000, pp.128-131.
- [4] R.S. Rawat W. M. Chew, P. Lee, T. White, Bing Shan, S. P. Moo, and S. Lee, Room Temperature Growth of Titanium Nitride Thin Films on Stainless Steel Using Plasma Focus Device, Proceedings of the Regional Conference on Plasma Research in 21<sup>st</sup> Century, Bangkok, Thailand, May 7-12, 2000, pp.122-127.
- [5] L. I. Ivanov, A. I. Dedyurin, I. V. Borovitskaya, O. N. Krokhin, V. Ya. Nikulin, S. N. Polukhin, A. A. Tikhomirov, “Material testing with the use of plasma focus device” ECA Vol. 28G, P- 31<sup>st</sup> EPS Conference on Plasma Phys. London, 28 June-2 July 2004 4.151 (2004)
- [6] S. Lee, B. C. Tan , S. P. Moo et al., A Simple Facility for The Teaching of Plasma Dynamics and Plasma Nuclear Fusion, Am. J. Phys. 56(1), January (1988) pp.62-68.
- [7] R. S. Rawat, P. Lee, T. White and S. Lee, Deposition of TiC Thin Films Using Dense Plasma Focus Device, 27<sup>th</sup> EPS Conference on Contr. Fusion and Plasma Phys. Budapest, 12-16 June 2000, pp. 484-487.
- [8]  
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- [9]  
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- [10] Sh. H. Al-Hawat, O. Othman, “Operation of a Plasma Focus Device with Energy of 2.8 kJ in Various Gases”, First Cairo Conference on Plasma Physics & Application” Cairo, Egypt, October 11-15 2003.



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[11]

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