A STUDY OF ION BOMBARDMENT TIME FOR COPPER SPUTTERING BY USING AN ARGON – ARC PLASMA

***Khalid A.Yahya ,**Riayhd K.A. Al-Ani, ***Sabah N.Mazher**
**Department of Physics, College of science, Al-Nahrain University*
*** Department of Physics, College of science, Al-Mustansiria University*
**** Department of Physics, College of science, University of Baghdad*

Abstract

An experimental investigation is carried out to study argon ion bombardment time for a disk sputtering pole which is made from pure copper of diameter 30 mm and impacted by argon ions of energy 120 eV. This ions are generated by magnetically confined ion source . The ion source consists of a tungsten filament of 0.2 mm diameter as a cathode pole, and a graphite plate with a slot which represents the anode pole , and the arc of plasma which confined by a homogeneous magnetic field .
A set of experiments are conducted to collect the sputtering copper atoms on a slab , for different values of argon ion densities and bombardment times . The results of the study show that the net mass of collective sputtered atoms and the thickness of layer are increasing as the bombardment time increases , and reach 273.2 mgm and 24.39 µm respectively for argon ion density $7x10^{18}$ m^{-3} and bombardment time 60 min .

دراسة زمن القصف الأيوني لترذيذ النحاس بإستخدام قوس بلازما الأركون

الخلاصة

أجريت تجربة عملية لدراسة زمن القصف لأيونات الأركون على قطب الترذيذ والمصنع من مادة النحاس النقي بقطر 30 mm وقد قصف بأيونات الأركون بطاقة 120 eV والمولدة بواسطة مصدر أيوني محزم مغناطيسيا.
يتألف المصدر الأيوني من فتيلة تنكستن بقطر 0.2 mm والتي تمثل قطب الكاثود وقطعة فيها شق من مادة الكرافيت تمثل قطب الأنود وأن قوس البلازما قد تم حصره بأستخدام مجال مغناطيسي منتظم.
مجموعة من التجارب أجريت لجمع ذرات النحاس المرذذة على شريحة زجاجية ولعدة قيم مختلفة لكثافة أيونات الأركون وزمن القصف .
نتائج هذه الدراسة بينت بأن صافي كتلة مادة الذرات المجمعة من االترذيذ وسمك الطبقات يزداد بزيادة زمن القصف وقد وصل الى 273.2 mgm و 24.39µm على التوالي لكثافة أيونات الأركون $7x10^{18}$ m^{-3} وزمن قصف مقداره 60 min .

Introduction

The sputtering phenomenon is a useful means of producing vapors of metallic materials for different uses, such as, mass spectroscopic studies and isotope separation [1,2,3]. Recently, they have become a tool in the research of interaction between solids and ions .Also they are useful in industrial technological procedures [4,5,6].
This technique enables one to introduce the accelerated ions into the surface layer of various

materials . The most important use of this technique seems to be in microelectronics. Other applications also assist in the production of conducting layers , high precision alloying of different materials or doping of material with impurities of given concentrations[7,8] .

In the present work, the method can be incorporated in most plasma sources by inserting a metal pole in the discharge . The pole is maintained at a negative potential with respect to the plasma and the pole material is subsequently sputtered into the discharge by a positive ion bombardment .

General design and construction

The present ion source whose operational characteristic are known [9] , shown in fig.(1) consists of the following :

(a) a cathode which is the filament(1) is made of tungsten wire of diameter 0.2 mm and length 65mm.

(b) an anode pole (2) which is made of graphite plate with a slot defining the cross section of electron stream, is called a ”defining slot “ of dimension (30x40)mm^2.

(c) a homogeneous electromagnetic field (3) (0-45)mT along the cathode –anode axis .

(d) insulators ,such as Teflon ,glass and ceramic .

(e) a disk sputtering pole (4) which is made of pure copper whose diameter 30 mm and thickness 10 mm.

Experimental measurements

A set of experiments are conducted , using argon ions . The vapor of pure copper is obtained and collected on a slab above the sputtering copper pole due to bombardment of argon ions which is generated in a gas discharge. The sputtering pole is kept at a negative potential of 120 Volt .

Influence of ion bombardment time on the net collective mass.

The operation conditions for the ion source and argon ion density n_i have been investigated [9] as in figure(2). This paper shows additional experiment to study the influence of the ions bombardment time, t_b, on the net collective mass, m_c , of the sputtered copper atom on the slab, which are measured by a sensitive balance , its sensitivity reached to 0.5 μgm , for different values of argon ions densities are demonstrated in figure (3) . The values of m_c increase as t_b increase .For example, when n_i = 6 x 10^{18} m^{-3} and t_b = 60 min, the maximum value of m_c is 273.2 ,as shown in table (I) .

Influence of ion bombardment time on the collective thickness

From the experimental results in figure(3) , the collective thickness d can be calculated theoretically of the collective copper atoms at the slab with dimensions (25x50x1)mm^3 from the following equation

$$d = \frac{m_c}{a\,b\,\rho} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

where a is the length of the slab , b is the width of the slab and ρ is the copper density .

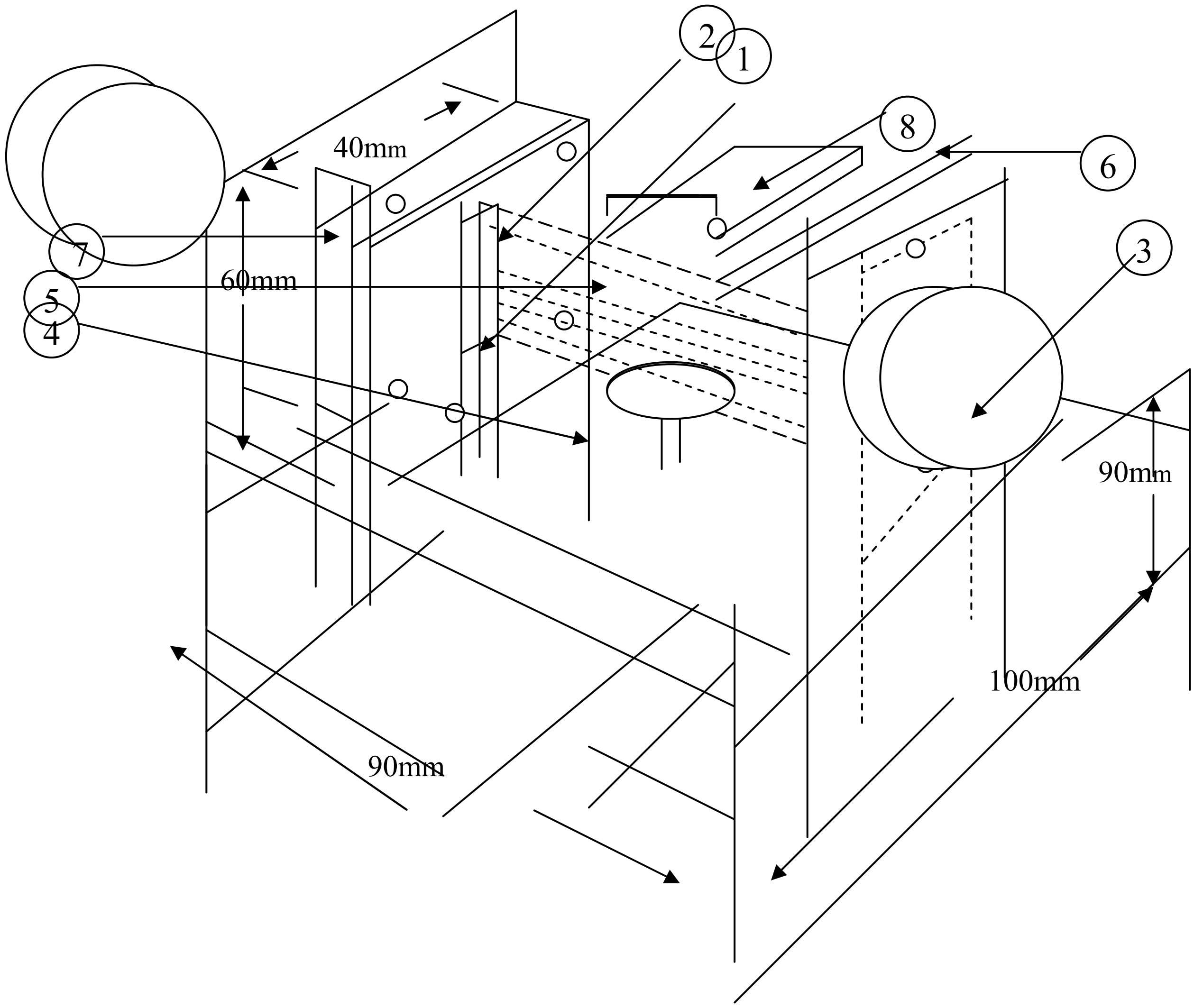
Figure(4) shows the calculations for d as function of t_b . It is found that the maximum values of d = 24.39 μm is obtained for ion density n_i = 7x10^{18} m^{-3} and t_b =60 min as shown in table (I) .

Conclusions

Several experiments have been carried out to study the ion bombardment time and the thickness of copper sputtered atoms for different values of argon ion densities .

It has been found that the increasing of ion densities has the same effect of the increasing of ion bombardment time .

This technique can also be developed in industry applications such as ,coating the materials which needs high temperatures .



No.	Description	Material
1	Filament	Tungsten
2	Anode pole (defining slot)	Graphite
3	External electromagnetic field	
4	Circle sputtering pole	Copper
5	Arc plasma for argon gas	
6	Gas tube	Copper
7	Insulator	Boron Nitride
8	Slab	Glass

Figure (1): A schematic drawing of the ion source

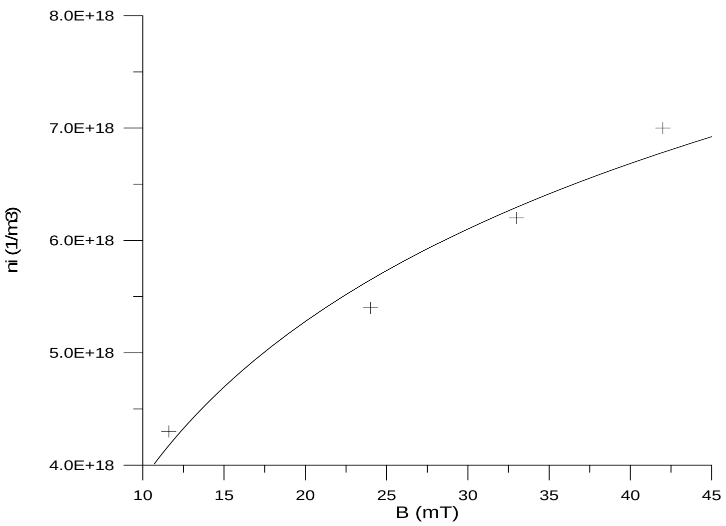


Figure (2): Argon ion density as a function of the magnetic flux density at arc voltage = 70 V , arc current = 400 mA and argon gas pressure = $8x10^{-4}$ mbar [9]

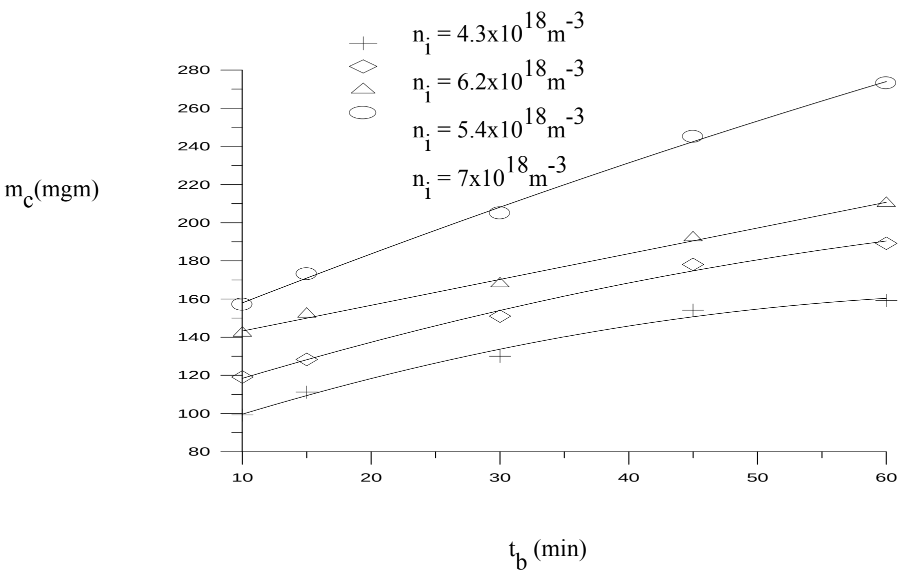


Figure (3) :The collective net mass as a function of ions bombardment time for different values of argon ion densities

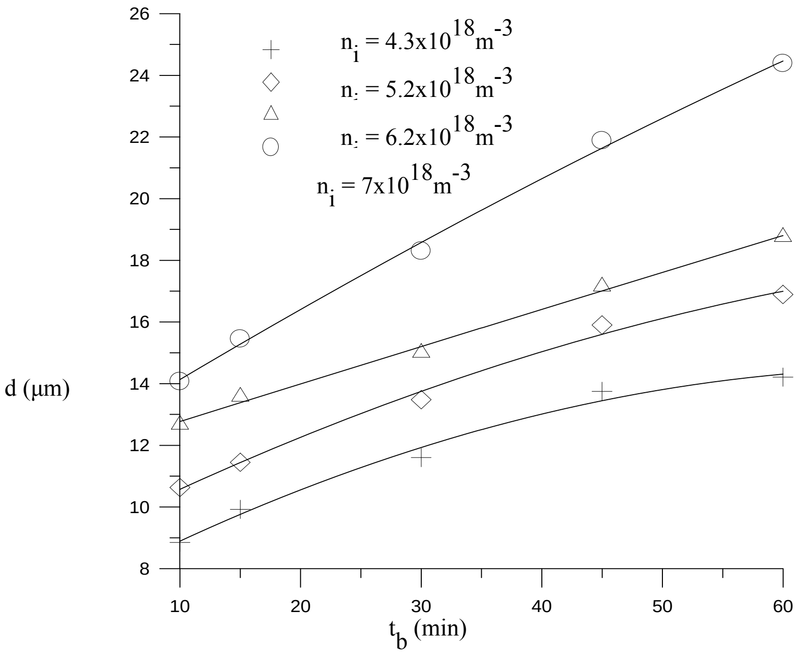


Figure (4) : the collective thickness as a function of ions bombardment time for different values of argon ion densities

Table (I) :Maximum values for net collective mass and collective thickness which are calculated from equation (1) for different values of argon ion densities at t_b = 60 min.

n_i (m^{-3})	m_c (mgm)	d (μm)
$4.3x10^{18}$	159.2	14.21
$5.4x10^{18}$	189.2	16.89
$6.2x10^{18}$	210.2	18.76
$7x10^{18}$	273.2	24.39

References

1. Deamaly.G,Freeman.J.H ,Nelson.R.S & J.Stephen , **1973** , " *Ion Implantation* " (North – Holland pup.co. Netherlands) .
2. Alton .G.D, **1981** "*A spect of physics , chemistry , and technology of high intensity heavy ion source* " Nucl.Instrum. and Meth. , **189**,15.
3. Kim.W , Choi.B.H ,Jin.J.T & Jung.K.S, **1993** , " *A new design of the sputter type metal ion source and its characteristics of ion beam extraction* "IEEE Trans. on plasma science , **10**, 3195
4. Azarenkov . N . A , Bizyukov . A . A &.Torasov.I.K, **2003** " *Solid ion source based on hollow – cylindrical magnetron sputtering discharge* " Plasma physics , 9, 125.
5. Ueda . M , Berni . L . A ,Castro . R . M &Lepienski.C.M, **2002** , " *Surface improvements of industrial components treated by plasma immersion ion implantation*" Surface and coating technology , 156,71.
6. Gulbinski.W.**2007**, " *Plasma source III sputtering source – magnetron sputtering* " (PPST plasma physics in science and technology , Greifswald , Poland) .
7. Chen.F.F, **1974** " *Introduction to plasma physics* ", (Plenum press , New York and London),
8. Wirz.R.E, **2005** " *Discharge plasma processes of ring- cusp ion thrusters* " Ph.D. Thesis , California institute of technology , Pasadena , California ,
9. Khalid A.Yahya , Mahdia H. Jasim & Anis K.Fawzi . **2007**, " *The characteristic study of an argon –arc plasma in type of ion source magnetically confined* "J. of college of Education , 3,615