Modified Surface for 2D-Corrosion Inhibitors

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ABSTRACT

Surface patterning have been investigated for the growth of 2D-corrosion inhibitors. The Si-surface by 10-12 keV Ar^+ ion bombardment at an oblique angle incidence of 75° for various ion fluences of order ~$3x10^{18}$ Ar^+ cm^{-2} at room temperature has been done to compare the surface to grow metal oxide, sulphide and other low cost corrosion inhibitors. The study shows that surface pattern at an angle of 75° is a better choice to develop the nano layer coatings of 2D-corrosion inhibitors. Some optical properties have also been observer as a key parameter to grow thin layer non-metallic corrosion inhibitors.

KEYWORDS : Corrosion Inhibitors, Metal Oxides, Optically Active 2D-Materials.

INTRODUCTION

Materials which protect a metal surface from being eroded or degraded are corrosion inhibitors. A corrosion inhibitor basically slows down the rate of corrosion of the metal surface on which it acts. They fall in category of anodic like chromates, tungstate, nitrites, molybdates, orthophosphates and cathodic like Na_2SO_3, Ni-salts, $Zn_3(PO_4)_2$. Two dimensional (2D) corrosion inhibitors like MoS_2, αMnS, organic corrosion inhibitors like benzotriazole, a heterocyclic compound with formula $C_6H_5N_3$ have received considerable attention including researchers [1, 2]. Corrosion inhibitors plays an important role in many applications and have been extensively developed during the past few decades because of advancements of technology applications. The demand of industry triggers the rapid growth of pollution and contamination for product quality control and health. The search for new development has given rise to rapid advances in semiconductor material technology recently. These semiconductor material based corrosion inhibitors provides many advantages for continuous development and is easy to integrate with exhisting inhibitors systems. But, the development of materials for inhibitors is very limited to inorganic semiconductor materials to some active and responsive polymeric materials. Some inhibitors also uses rare earth metals for fast response [3, 4]. The rapid growth of industries leads to the concentration of pollutant, hazardous and poisonous corrosion in the environment by Cl-complex, PH_3, NO-complex, SO-complex, NH_3, CO_2, CO, SO_3, CH_4, H_2S, etc. Over the past several decades, metal oxides like CuO, ZnO, Si-TiO_2, Si-SnO_2, Co_3O_4, WO_3, Cr_2O_3, etc have been extensively used for corrosion inhibitors applications due to their low cost and simple mechanism [5, 6].

The properties of these metal oxides change upon exposure and contact to various corrosion. There are many inhibitors made of metal oxides which are used for detection of flammable, reducing or oxidizing corrosion by conductive measurements [7]. These oxides are ZnO, SnO_2, TiO_2, Cr_2O_3, Mn_2O_3, MoO_3, Al_2O_3, Ta_2O_5, In_2O_3, MgO, WO_3, V_2O_3, Fe_2O_3, La_2O_3, CeO_2, Nd_2O_3, Co_3O_4, NiO, CuO, SrO, GeO_2, Nb_2O_5 [8, 9, 10]. Metal oxides selected for corrosion inhibitors are identified from their electronic structure. Some transition metal oxides are quite inert because they have large band gaps [11, 12, 13]. Neither electrons nor holes can easily be formed in their sites.

EXPERIMENTAL

Cleaved silicon surface of area 1 cm^2 were irradiated by 10-12 keV Ar^+ ions at an oblique incidence angle 75°with respect to surface normal have been done. These samples were sputtered with Ar^+ ion beam having low energy to a dose of 3×10^{18} Ar^+cm^{-2}. Electron Cyclotron Resonance (ECR) ion source was used to carry out this research. Uniform irradiation was achieved by scanning the beam over the Si (100) samples. The ion fluences were varied from 1×10^{17} to 3×10^{18} Ar^+/cm^2. The average ion beam current was around 5A. The target chamber and plasma chamber were maintained in high vacuums ~10^{-7} mbar which was reduced during irradiation. The morphology of the irradiated silicon samples were investigated using Atomic Force Microscopy (AFM), Multi-Mode AFM instrumentation. The AFM surface morphology of all the samples was taken in contact mode. The surface rms roughness and other statistical information of the surfaces were extracted from the AFM images using WSxM and further statistical analysis were done to study the optical parameters of ripples.

RESULTS

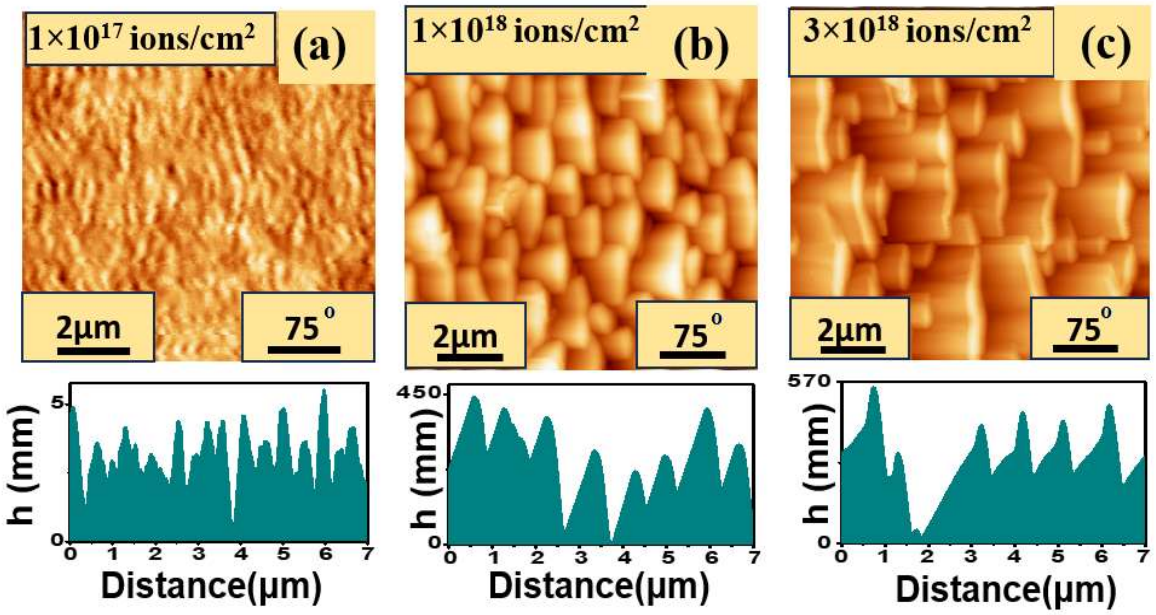

Fig 1 : Surface Morphology of Si-substrate at 75˚ of ion fluence.

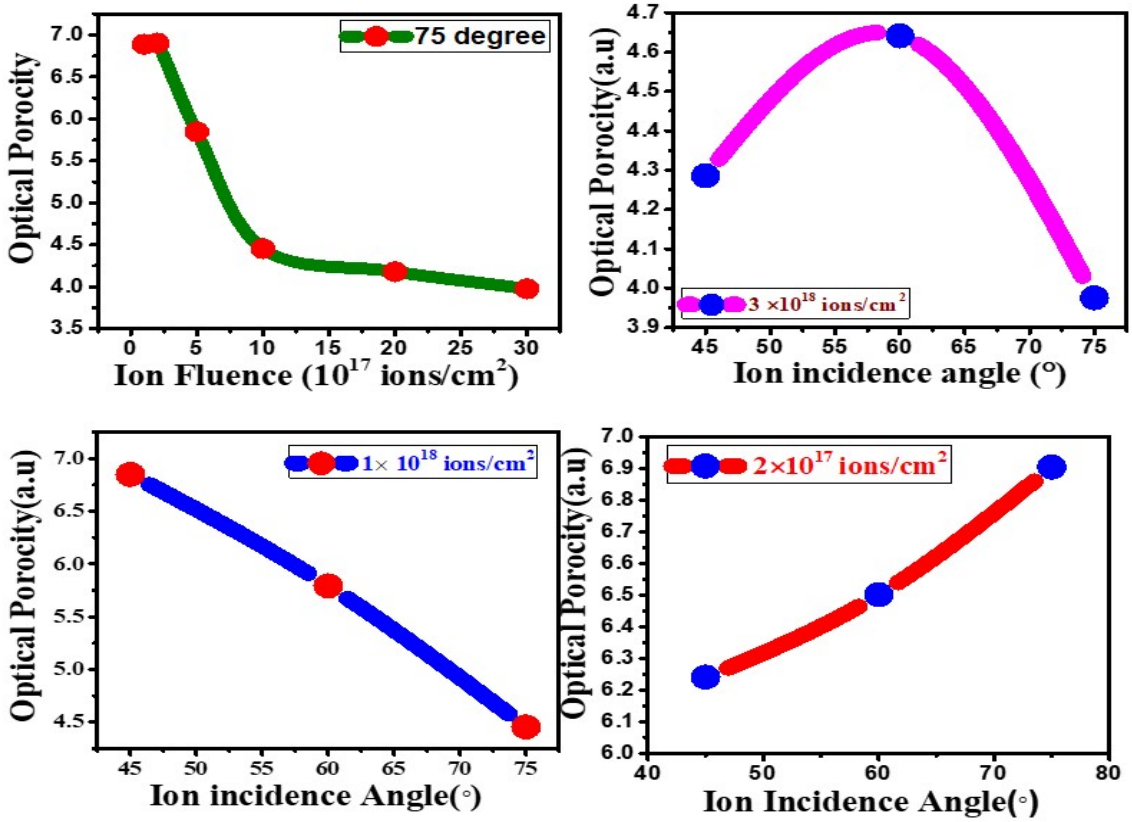

Fig 2 : Optical properties at an angle of 75˚ variations with varying ion fluences.

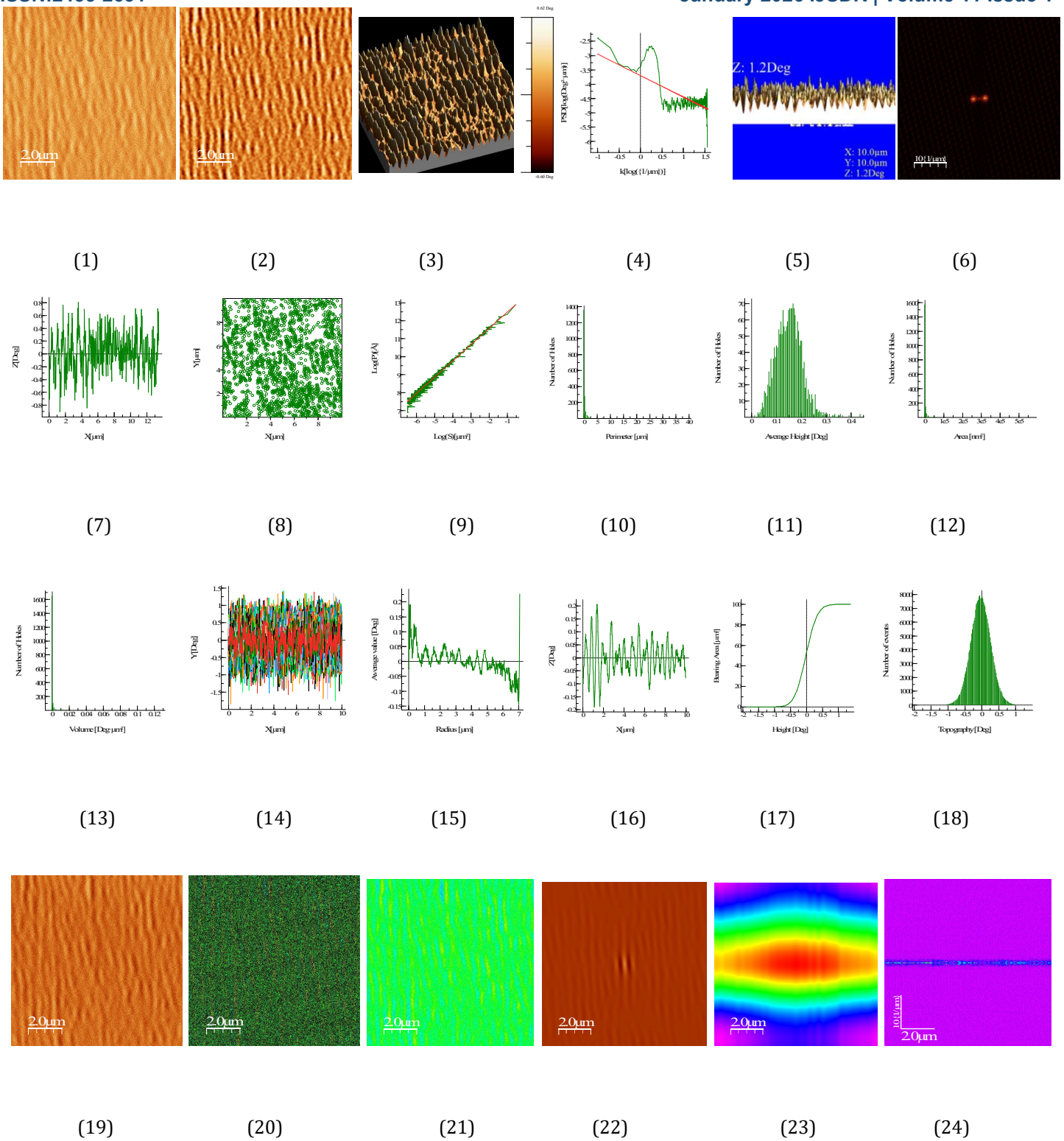

Fig 3 : (1) Actual AFM micrograph of Si ripples at 75° Ar^+ ion irradiation , (2) Equalized image morphology, (3) 3D View morphology, (4) Power Spectral Density, (5) Cross 3D view, (6) 2D FFT, (7) Z-Profile for fig (1), (8) Center Hole Plot, (9) Fractal analysis, (10) Hills vs. Perimeter Histogram, (11) Hills vs. Average Height Histogram, (12) Hills vs. Area Histogram, (13) Hills vs. Volume Histogram, (14) Image to Curve Plot of Y-axis, (15) Radial Averages, (16) Arbitrary Z-Profile for fig (1), (17) Bearing Area Plot, (18) RMS Roughness Analysis, (19) Convoluted Image, (20) Ripples contours morphology, (21) Image palette spectrum, (22) Wavelet profile, (23) Wavelet analysis spectrum morphology, (24) 1D-FFT columns.

DISCUSSIONS

The scientific corrosion literature has lists of many materials that exhibit inhibitive properties such as oxides, sulphides, etc. Actually, few inhibitors were used in practice according to the desirable properties of an inhibitor for metal protection. There are several considerations when choosing an inhibitor in regards to cost, toxicity, availability and environmental friendliness[14, 15, 16]. Irradiation on metal surface for inhibitors application plays a vital role in the fabrication as well as the sensitivity of the inhibitors. An irradiated substrate enhances the capability of the inhibitors performance. A corrosion inhibitors utilizes the mass sensitivity with the help of a selective chemical coating on the surface [17, 18]. This chemical coating absorbs the target corrosion and influences the mass loading of the inhibitors. The most important part of corrosion inhibitors is the surface which interact with the corrosion molecule [19]. A surface sensitive inhibitors works on a very simple principle that on exposure to a target corrosion in air at an elevated temperature, the resistance of internal circuitry either decreases or increases as a function of the partial pressure of the corrosion on the substrate used which is generally silicon [20, 21, 22]. Metal oxide semiconductor corrosion inhibitors is used to detect redox reactions of corrosion on the semiconductor surface. The direct reactions of the corrosion with surface defoliates the ripples on the substrate [23, 24]. An ideal corrosion inhibitors should exhibit high sensitivity, low detection limit, selectivity, a very fast response time and stability over a long period [25]. The optical porosity get drastically reduced at higher degrees of ion fluence which shows that corrosion inhibitors can sustain longer period on the surface [26, 27, 28].

CONCLUSIONS

High selectivity is one of the critical requirements for making practical corrosion inhibitors [29, 30]. The instability in corrosion inhibitors causes pseudo alarms and attracts a high cost due to the replacement of corrosion inhibitors. Response and recovery time are also very crucial for making ultrafast corrosion inhibitors [31, 32]. But, in practical senerio, the widely used corrosion sensing metal oxide materials such as Cu_2O, TiO_2, ZnO, Fe_2O_3, SnO_2, Ga_2O_3, MnS, SnS are the most least-active with their chemical catalytic point of view [33, 34]. The pure SnO_2 thin film without any catalyst exhibits a very poor sensitivity. An ion irradiated modified surface acts as a very good surface to sustain the corrosion inhibitor layer deposited on them [35]. Metal oxides, sulphides react significantly to hold the surface firmly on them.

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DATA AVAILABILITY STATEMENT

All the data are provided in this research paper.

CONFLICT OF INTEREST

The authors declare no known competing interests.

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