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Application of ECR Ion Beam Irradiation for Micro Nano Square Hole Fabrication.

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Abstract

The fabrication in micro nano scale in nanotechnology world becoming greater and greater. Micro nano fabrication technologies serves several modern industries and technology especially IC industry, MEMS, solar cells, optoelectronics and flat panel display. In this current paper describes square hole fabrication in micro nano scale using ECR ion beam irradiation system on Silicon surface. Ar^{+4}, were irradiated at 400keV accelerating energy through a stencil mask on Silicon. Finally the size of the fabricated square hole and surface roughness of fabricated portion were measured by AFM and discuss briefly.

Keywords: Electron Cyclotron Resonance, ion beam irradiation, Atomic force microscopy.

Introduction

For nano scale fabrication and modification heavy ion beams are very important. Researchers are trying to develop several fabrication methods by using ion beams. Most of them use highly charged ion beam. This current experiment highly charged ion (HCI) was used too due to several advantages and unique features including high reactivity and stopping power enhancement [1]. The HCI effect is caused by the large reaction crosssections and large Coulomb potential of the ions. HCI effect could also realize more efficient and unique fabrication of materials particularly for insulators. Silicon was used in the present experiment as silicon is the workhouse of

microfabrication. Besides silicon is useable in a wide variety of sizes, shapes and resistivities: it is smooth, flat, mechanically strong and low cost [2].

Experimental Details

Working Principle

Hot-plasma ion sources or Electron Cyclotron Resonance (ECR) ion sources and their operation principle is schematically shown in Fig 1 [3]. During electrons movement in a magnetic field they gyrate around the magnetic field lines due to the Lorentz force. The gyration frequency is called the angular cyclotron frequency ω_{cyc}. If microwave radiation of the same frequency propagates into such a region, the electrons are resonantly accelerated or decelerated (depending on the phase of their transversal velocity component with respect to the electric field vector) when the electron cyclotron resonance condition is fulfilled:

$$\omega_{hf} = \omega_{cyc} = (e/m) \times B$$

Here, e and m denote the charge and mass of the electron, respectively.

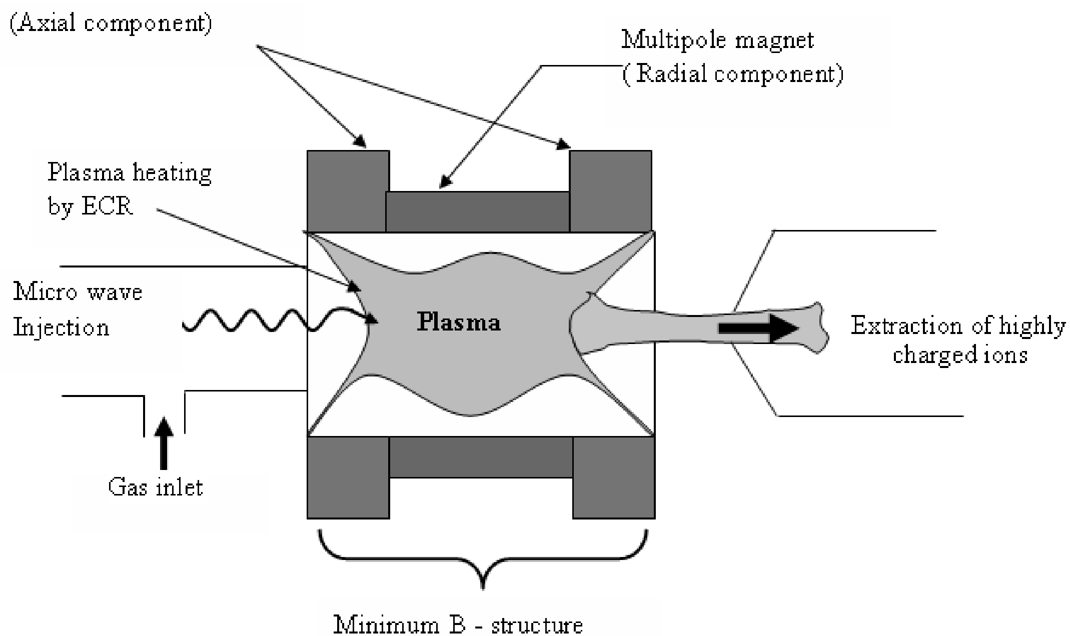

Figure 1: Operation principle of an ECR ion source.

The beam quality is determined by parameters like extraction voltage and geometry, intensity, magnetic field in the extraction region, etc. After the extraction the beam widens up because of its space charge. However, by using ion-optical elements it can be focused again and adapted to the following beam line.

Experimental Procedure

The experiment was completed by a 10- GHz NANOGAN ECR ion source installed at Kochi University of Technology (KUT). The experimental set up is shown in Fig 2. For the current experiment, room temperature Ar^{+4} ions with energy 400 keV were irradiated on Si through a Cu stencil mask. The dimension of the used mask thickness was 10 μm with square hole size 43μm × 43 μm. For the above energy the dose on sample was 500 qμC/cm^2 where q denotes the charge states of the irradiated Ar ions. After ion beam irradiation the fabricated surface was analyzed by atomic force microscope (AFM).

Figure 2: ECR Ion beam set up at KUT.

Results and Discussion

By AFM analysis, it is found the fabricated square hole size is 43μm × 43 μm for 400 keV accelerating energy. The depth of the micro machined is portion is 12.18nm. Figure 3 shows the AFM image of fabrication of micro nano square holes by using ECR ion beam. It was also measured the surface roughness by using AFM in the fabricated surface. The roughness of fabricated portion was 18.915 nm. During surface roughness measurement two points were chosen freely. Figure 4 shows the AFM analysis for roughness measurement. The vertical distance between two points was 5.466 nm and the horizontal distance between two points was 9.688 μm

Conclusions

Fabrication in micro and nano scale is the outgrowth and extension of nanotechnology. Recently nano fabrication application increases due to developments in mechatronics and robotics. Their structures and mechanism become more complex

and they require different types of micro nano fabricated parts. Various researchers are working to develop new technique for fabrication in small scale. The current paper describes one of the recent easy techniques for fabrication of square hole by using ECR ion beam irradiation. The surface roughness between two correlation length also discuses briefly. Finally further analysis regarding the shape of the fabricated surface by changing the main experimental parameters to establish a relation among main parameter and surface roughness and its correlation length. It believes this new application of ECR ion beam for micro nano fabrication will help to fabricate different parts used in nanotechnology world.

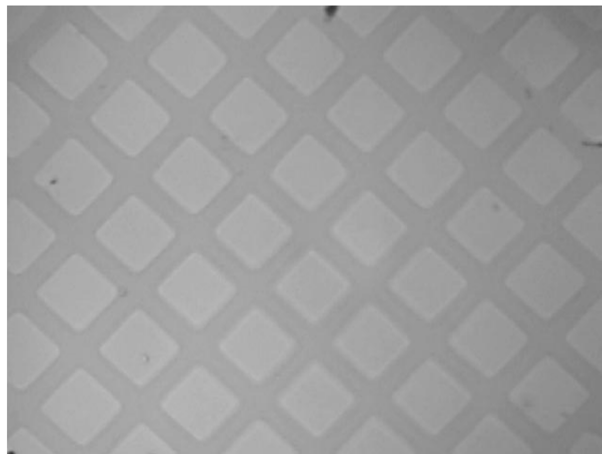

Figure 3: AFM image of fabricated surface.

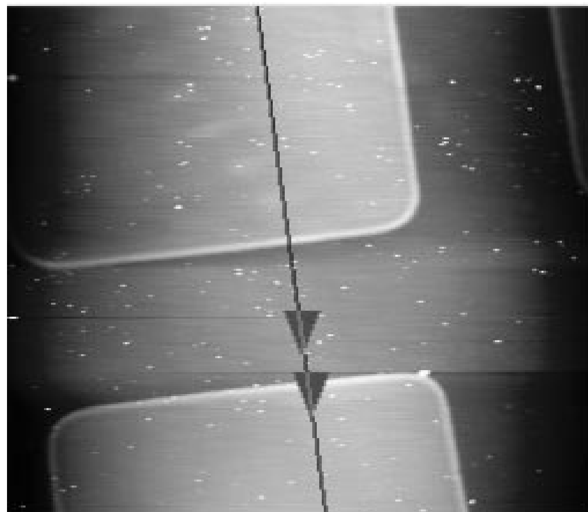

Figure 4: AFM analysis of fabricated area.

Acknowledgements

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