Equipments in Soft X-Ray CVD Beamline

Masanori OKUYAMA

1. Introduction

Technological innovation of growth and etching has been sincerely desired in electronics manufacturing in order to create new functional materials and prepare conventional electronic materials at low temperature. Strong soft X-rays from undulator in synchrotron storage ring is expected to solve these requirements. Because, atoms could be excited very much, and extraordinary chemical reactivity is caused by remarkable dissociation and multi-ion production consequently. Therefore, CVD and etching technique used strong soft X-rays are paid to great attention, and reaction mechanism of deposition and etching should be clarified to carry out these processes effectively by sophisticated characterizations which includes in-situ observation as an excellent monitoring of the radial reaction.

2. Outline of Beam Line Configuration and Experimental

2-1 Optics

The optics of the beamline is shown in Fig. 1. Synchrotron radiation from the soft X-ray undulator is introduced into the soft X-ray CVD beam line by a mirror M0. The beamline consists of two branches: 1) one is for micro-beam, 2) and the other is for direct-beam. The reaction chamber is shared between direct-beamline and micro-beamline.

1) Micro-beam is generated by focusing direct-beam with two SiC plane-ellipsoidal mirrors M. M are accommodated in a mirror chamber next to a gate valve and a beam position monitor. The mirrors are used with the incident angle of 89 ° to cover up to the photon energy of 5 keV. The plane-ellipsoidal mirrors are designed to give the demagnification of 1/50, and the spot size on the sample is expected to be several ten μm in both vertical and horizontal directions. A small spot size is obtainable by restricting the divergence of the radiation with an aperture which consists of water-cooled slits. These slits are accommodated in the mirror chamber along with a beam position monitor.

2) The soft X-rays introduced into the direct-beamline irradiates the sample directly, thus the spot size on the sample is several mm in the vertical and horizontal directions. If a larger irradiation area is necessary, a movable stage should be installed into the reaction chamber.

2-2 End stations

Research in this beamline is classified into some topics. For etching, reactions and desorbed products are probed, and the surface profiles are observed to clarify the mechanisms. For the CVD experiments, the grown films are to be evaluated using various techniques.

Almost all of the users wish to make in-situ characterization of surface, structure and composition of the irradiated substrate or grown films under SR irradiation. For this purpose, this station must be equipped with conventional instruments which enable one to characterize the structural and elemental information of the grown films using well established techniques. In order to control a reaction process, one should be able to control various experimental parameters such as photon energy and intensity, substrate temperature, and reactant gas pressure, until the best set of experimental conditions is found.

2-3 Experimental Station

Experimental station consists reaction chamber, analytical instruments and gas supply and toxic gas treatment system.

Schematics of the experimental station is illustrated in Fig. ??. It comprises an ultra-high vacuum reaction chambers, an analysis chamber, and a differential pumping chamber. They are desired to be set vibrationless bench, so that the position of the specimen to be irradiated is accurately controlled within some μm. The reaction

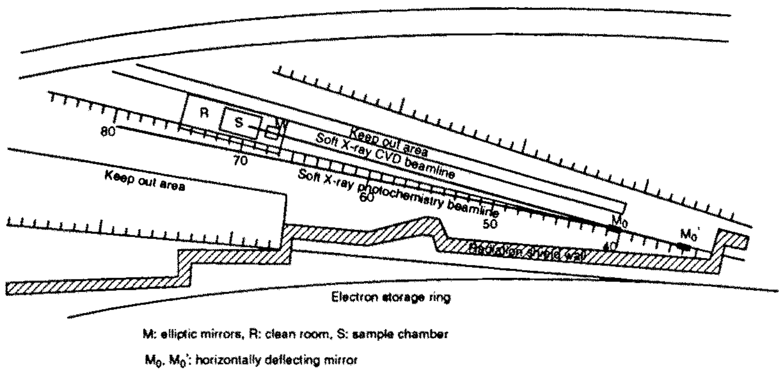

Fig. 1 Soft X-ray CVD beam line

chamber is connected through an orifice of 2 mm in diameter whose position can be accurately adjusted. Reaction chamber position is movable to be aligned along with both direct beam and diffracted micro-beam.

Auger electron spectrometer (AES) and X-ray photoelectron spectrometer (XPS) is desired to be installed to obtain in-situ information on time-transient of the chemical compositions of irradiated specimen surface. Electron energy spectrometers which are capable of two dimensional determination of chemical compositions on the irradiated surface will be essential, especially when synchrotron radiation is introduced through a mask. Reflected high energy electron diffraction (RHEED) and Fourier-transformation infrared spectrometer (FT-IR) are used to examine the cleanliness and absorbed specimen on surface before/after irradiation, and also to evaluate the crystallinity of formed films. Scanning probe microscopes would be essential to monitor the changes in atomic scale surface morphology. Many of the interesting compound bulk and films formed by photochemical reactions with SR may be easily oxidized in the atmosphere, thus it is essential that the analysis chamber with analytical instruments is directly connected to the reaction chamber. Addition these, the temperature on surface can change very rapidly with SR irradiation, and the temperature profile affects the surface reaction very much. Thus, it should be measured with a high speed IR camera. One may need a differentially pumped mass spectrometer detector or particle detection systems employing laser induced fluorescence or laser multiphoton ionization spectroscopy as well as an optical multi channel analyzer system.

In order to use toxic reactive gases and to comply with the toxic gas handling law, detoxic system should be installed. A gas-leakage warning system and automatic shut-off system of gas supply lines will be installed to make secure the handling of combustible and toxic gases.

3. Introduction

Ultra-high vacuum reaction chamber, analysis chamber and differential chamber will be constructed this year. We hope that the other equipments will be admitted to be financed.

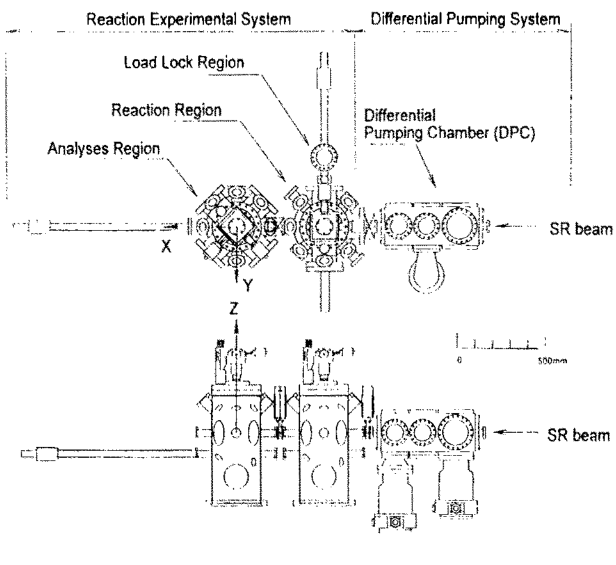

Fig.2 Schematic diagram of experimental station