Soft X-Ray CVD Beamline

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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 is expected to solve these requirements. Because, atoms could be excited very much by core electron excitation, and extraordinary chemical reactivity is caused by remarkable dissociation and multi-ion production consequently. Therefore, CVD and etching technique using strong soft X-rays are paid to great attention, and reaction mechanism of deposition and etching should be clarified by sophisticated characterizations which includes in-situ observation as an excellent monitoring of the radial reaction.

2. Light source

Figure-8 undulator [1)] is used in soft X-ray CVD beamline. The electron orbit projected on the transverse plain has an eight-figured shape in this undulator. The electron moves clockwise and counterclockwise alternately, and therefore, the polarization is liner since the component of circular polarization is canceled out.

The photon energy is variable from 0.5 to 5 keV. Peak brilliance of 1.1 × 10^{18} photons/sec/mrad^2/mm^2/0. 1 %b.w. is expected at photon energy 500 eV and beam current 100 mA. The total power of figure-8 undulator is estimated to be 2.7 kW, and power density is estimated to 1.7 kW/mrad^2 (when 1st harmonic is set to be 500 eV). The flux power is estimated to be about 10^{12} photons/sec at E/DE=10,000 on a sample.

3. Optics

The optics of the beamline is shown in Fig.1. Soft X-rays from the figure-8 undulator is introduced into the soft X-ray CVD beamline by mirror M_0'. The beamline consists of two ranches: 1) one is for micro beam, 2) and the other is for direct beam. The reaction chamber is shared on moved horizontally between direct beam and micro beam.

1) Micro beam is generated by focusing direct beam with two SiC ellipsoidal-cylindrical and one plain minors (M1'-M3'). These mirrors are accommodated in a mirror chamber. The mirrors are used with the incident angle of 89° to cover up to the photon energy of 5 keV. These ellipsoidal-cylindrical mirrors are designed to give the demagnification of 1/50, and the spot size on the sample is expected to be several ten mm in both vertical and horizontal directions.

2) The soft X-rays introduced into the direct-beamline irradiates the sample directly, thus the pot size on the sample is several mm in the vertical and horizontal directions.

3. End Station

Experimental station consists reaction chamber with loadlock system, analysis chamber, differential pumping chamber and gas supply. We hope analysis instruments and toxic gas treatment system are installed.

Schematics of the experimental station is illustrated in Fig. 2. It comprises an ultra-high vacuum reaction chambers (5x10^{-10} Torr), an analysis chamber (2x10^{-10} Torr) and a differential pumping chamber. They are desired to be set on vibrationless bench, so that the position of the specimen to be irradiated is accurately controlled within some mm. The reaction 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 micro beam.

Differential pumping chamber is set to irradiate SR light to sample and reaction gas directly. Because, there are no window material transparent to soft X-rays. Using this differential pumping system, gas can be introduced at pressure 0.1 Torr in reaction chamber.

Moreover, the sample can be cooled down to -140˚C and be heated up to 1000˚C .

Many of the interesting compound bulk and films prepared by photochemical reactions with SR may be easily oxidized or contaminated in the atmosphere, and thus it is essential that the analysis chamber with analytical instruments is directly connected to the reaction chamber. The analysis chamber is designed to be utilized for AES, XPS, FT-IR and RHEED measurements. AES and XPS is desired to be installed to obtain in-situ information of irradiated specimen surface. Electron energy spectrometers which are capable of two dimensional determination of chemical compositions on the irradiated surface will be essential. RHEED and FT-IR can be used to examine the cleanliness and adsorbed specimen on surface before/after irradiation, and also to evaluate the crystallinity of deposited films with CVD or ablation.

In order to use toxic reactive gases and to handle the toxic gas, detoxic system are should be installed. A gas-1eakage warning system and automatic shut-off system of gas supply lines will be installed to make secure the handling of combustible and toxic gases.

Reference

[1] T. Tanaka, H. Kitamura: Nucl. Instr. and Meth. in Phys. Res. A **364** (1995) 368-373.

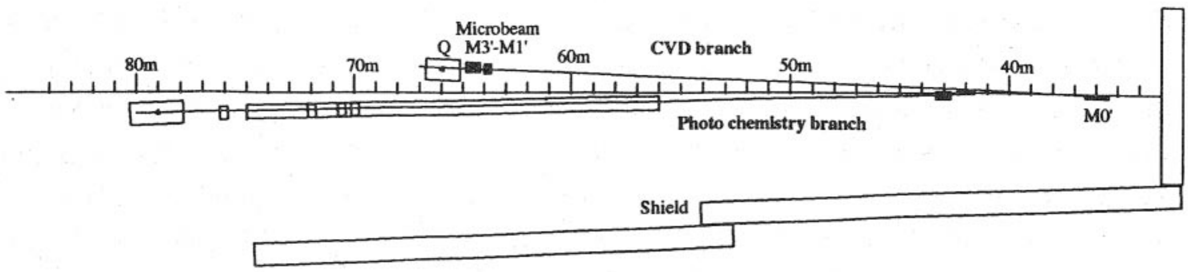

Fig 1. Soft X-ray CVD beamline.

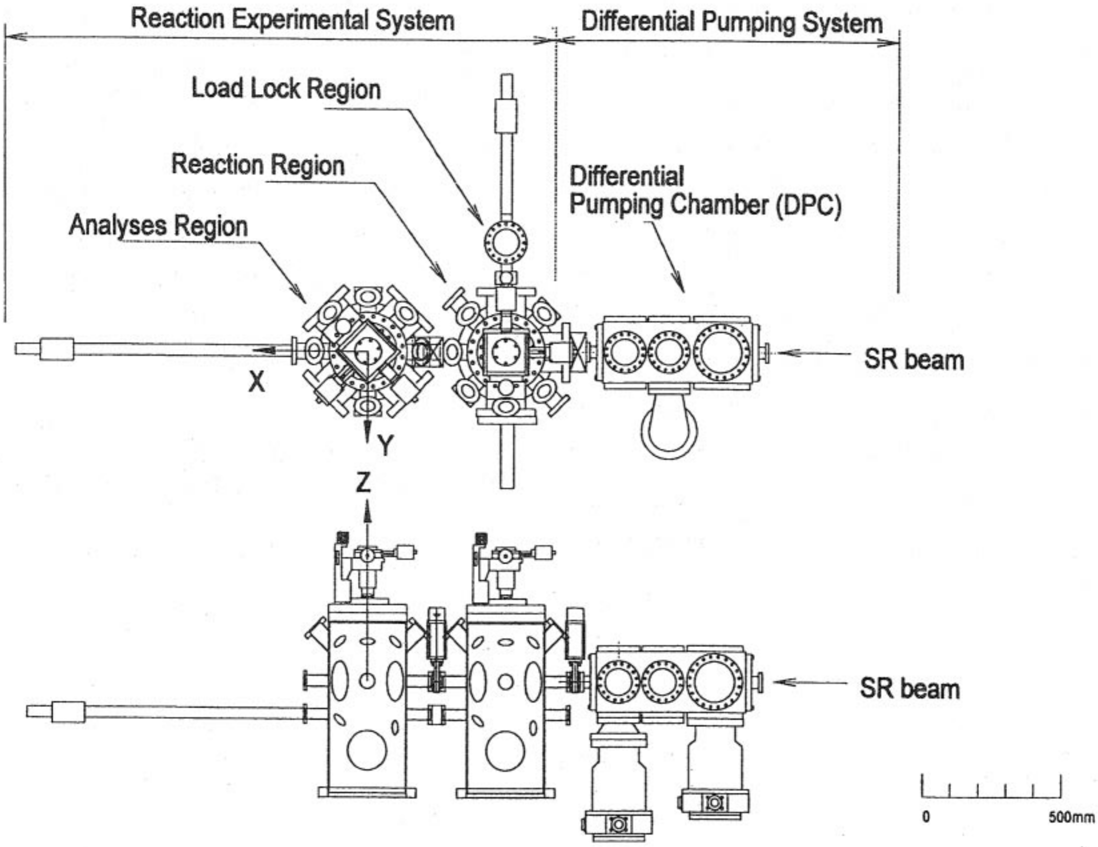

Fig 2. Schematic diagram of experimental station.