Thin film deposition using synchrotron radiation-induced CVD and ablation

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Thin film deposition method using strong soft X-rays have been paid much attention because of extraordinary chemical reactivity due to the core electron excitation. In order to investigate the reaction mechanism of the film deposition, figure-8 undulator installed in BL27SU has wide range of photon energy compared with other facilities. However, this beam line is now under constructing, and thus, it is difficult to investigate the CVD processes till now. Another important process is the surface degradation by the soft x-ray irradiation during and/or before the film deposition.

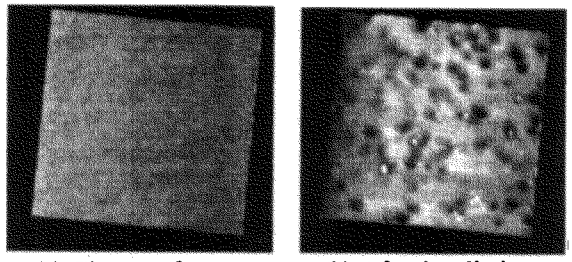
In this experiment, we investigate an effect of soft x-ray irradiation on substrate surface, which would be degraded by high energy photon.

We used MoS_2 as the substrate because a clean surface can easily be obtained by peeling off the surface layer and the surface is not oxidized. This character is effective to investigate the soft x-ray radiation-induced surface degradation by using ex-situ scanning tunnel microscope (STM) observation. The sample was set in the end station, and the irradiation was carried out in vacuum at room temperature. The undulator gap of 40mm corresponding to 1st order photon energy of 304eV was used. Total dose was in the range of 300-11000 mA·min.

The surface structure was observed by STM with constant height mode. The image are measured with the bias range of $\pm$0.15V.

Figure 1 (a) shows the STM image of MoS_2 clean surface on 100nm×100nm scale with the sample bias voltage of -0.15V. The atomic structure in the top layer of sulfur atoms is clearly seen. On the contrary, two kinds of images are observed on the sample irradiated with the soft x-ray, i.e., one is dark spots and the other is bright spot located at the center of dark circular image. Both types of images are observed from the MoS_2 surface, for which undulator radiation with photon energy of 36eV is irradiated From the careful analysis, the dark spots are considered to be low area at a landform. The bright spots are located in the dark circular image, and are believed to be some electronic structure located at bottom of the dip. Therefore, irradiation of soft x-ray leads to a formation of surface defects. In order to achieve high quality functional thin films by using soft x-ray excited CVD, it is important to know the formation mechanism and the influence on the film growth. Further investigations such as photon energy dependence are required to clarify the mechanism.

In summary, effects of soft x-ray irradiation on the semiconductor surface have investigated using STM. The soft x-ray irradiation modified the MoS_2 surface. The modified structures were similar to those of the results obtained at UVSOR.



(a) Clean surface (b) After irradiation

Fig.1. STM images of MoS_2 for (a) clean and (b) irradiated surfaces. Soft X-ray irradiation dose is 11000mA·min. The imaging area is 100nm□.