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Development of a three-dimensional scanning photoelectron microscope (3D-nano ESCA)

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Introduction

Recently, electronic devices such as LSI and hard disk drive become reduced in size for higher performance rapidly. With the miniaturization of these devices, tens of nanometer-size device elements have been fabricated. For further improvement of device properties, it is necessary to analyze depth profiles of electronic states on the nano scale. However, there have been no measurement methods to meet these requirements. Although Rutherford Backscattering Spectrometry (RBS) can provide information on the depth profiles, the spatial resolution is not enough for the micro/nano region analysis. In contrast, scanning photoelectron microscopy (SPEM) can provide chemical information in the micro region, but the depth profile is not possible. To enable both the nano region analysis and the depth profile analysis, we have developed a three-dimensional scanning photoelectron microscope (3D-nano ESCA).

Instruments

Figure 1 shows schematic illustration of the 3D-nano ESCA system. The optic system consists of a zone plate (ZP) and a pinhole that serves as an order-sorting aperture (OSA). The ZP central stop and the OSA are used to eliminate the unnecessary diffraction order radiation in order to achieve high signal to background (S/B) ratio. The diameter of the ZP is 200 μm, and the outermost zone width is 35 nm. The ZP can focus the synchrotron radiation on the 200 nm size at 1000 eV when the distance between light and ZP is 3.6 m theoretically. The diameter of the OSA pinhole is 50 μm.

The sample drive system consists of a combination of stepper motors for coarse scanning and the piezoelectric positioners for x-y fine scanning. The coarse stage allows 20 mm travel in the x and y directions with the accuracy of 5 μm. The fine stage piezomotor moves 100 μm in the x and y directions and allows operation with the accuracy of 2 nm.

Scienta R3000 is used as an electron spectrometer.

Measurements

The spatial resolution was determined by taking the line scans of the MCP screen current with the cleavage plane of the GaAs as a knife-edge. When the distance between light source and ZP is 3.6 m at 1000 eV, the vertical and horizontal spatial resolutions are estimated to be 370 nm and 540 nm, respectively.

As a scanning photoelectron measurement sample we used an Au mesh. The Au mesh has intervals of 5 μm and the mesh line-width is also 5 μm. Figure 2 shows a photoelectron image of the scanned Au mesh. The image size is 50*50 μm^2 with dwell times of 10 second and the step size is 1 μm. The image of Au 4*f* certainly reflects the Au mesh configuration.

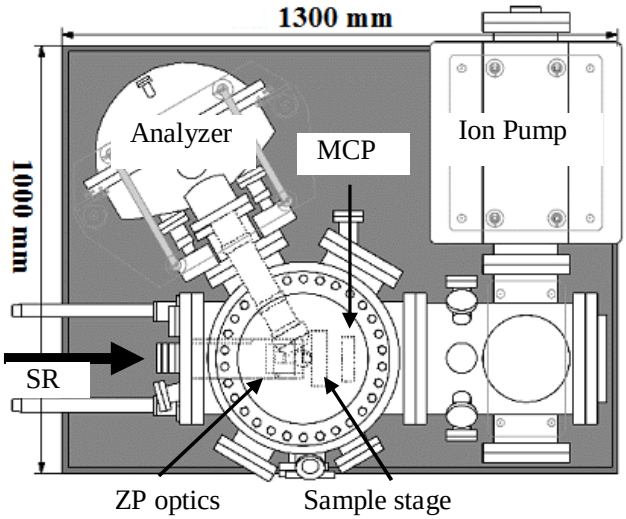

Fig. 1. The schematic illustration of 3D-nano ESCA system

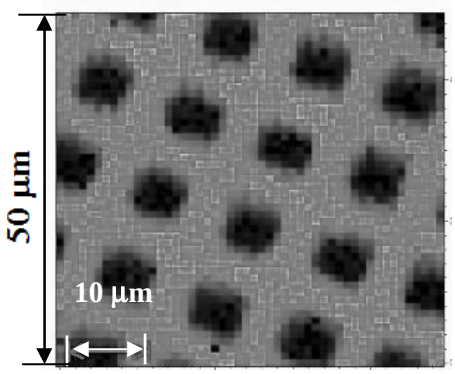

Fig. 2. The Au 4*f* photoelectron image of the Au mesh

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