5 Slow Positron Facility

Development of a Transmission Positron Microscope

A transmission positron microscope (TPM) has been constructed at the slow positron beamline at the KEK LINAC. The project was directed by Associate Professor Masanori Fujinami of the Faculty of Engineering of Chiba University in collaboration with the Japan Electron Optics Laboratory (JEOL), and supported by the Japan Science and Technology agency (JST). Transmission positron images and diffraction patterns have been acquired for the first time ever.

Some laboratories have previously performed positron transmission experiments, but the detailed behavior of positrons within specimens has not been sufficiently studied yet. The differences in transmission between positrons and electrons provide useful information on the basic scattering phenomena. The construction of a TPM promises new applications using the matter-dependencies of positron and electron transmittances. Several serious issues have been overcome to date in forming a positron microbeam for the TPM.

The intensity of a positron beam produced using a radioisotope such as ^{22}Na and a moderator is very low compared with that of a beam of electrons from an electron gun. Therefore the slow positron beamline at KEK was utilized in order to obtain an intense positron beam [1]. A microbeam for the TPM was obtained by employing a brightness enhancement technique with a transmission type remoderator, which consists of a Ni(100) single crystal of thickness 150 nm [2]. The transmission optics provides efficient focusing of the positron beam, the extraction of the positrons from the transport magnetic field, and allow for simple beam control [3].

The 35 keV positron beam was transported in a magnetic field to the experimental area from the thin tungsten moderator plate located in the target chamber. The beamline was connected to the top part of a conventional TEM (JEM-1011, JEOL) through the microbeam forming section. There, the beam was focused with a magnetic lens on to the Ni(100) thin-film remoderator, which was floated at 30 kV. The beam diameter was estimated to be 2 mm. Positrons injected into the remoderator are rapidly thermalized and diffuse to the back surface. These diffused positrons are re-emitted in a direction normal to the surface, since positrons have a negative work function (−1.0 eV) for Ni(100). The brightness was thus enhanced, due to the reduced divergence of the beam. The reduction ratio and the re-emission efficiency for the primary positron beam were estimated to be 1/10 and about 0.1, i.e., the brightness was enhanced by a factor of ten.

The positron microbeam was transported into the TEM with electrostatic lenses. The optics in the TPM is similar to those of the TEM. The positron and electron beams were focused at the same crossover point, and could be switched using a sector magnet at the top of the instrument. Thus same region of the specimen could be observed using both positrons and electrons. Transmission positron images of a 10 nm thick Au(100) sample were acquired at 3000-fold magnifications. The diffraction pattern of the Au(100) was also measured using positrons.

REFERENCES

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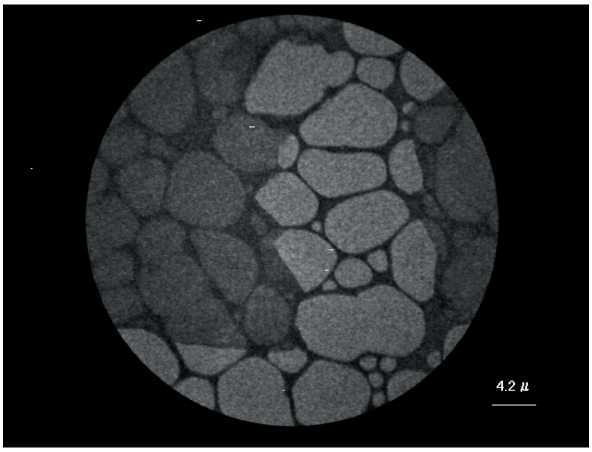

Figure 1
Transmission positron micrograph for Au(100) with 10 nm thick supported by a polymer mesh.

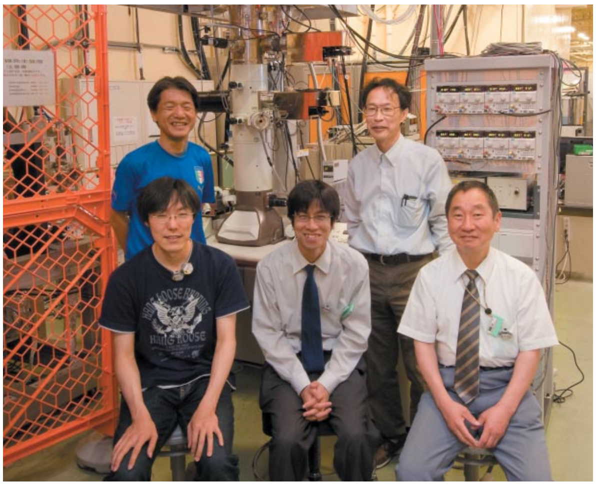

Figure 2
A photograph with the TPM.