3 Slow Positron Facility

Introduction

Positron spectroscopy based on intense positron sources such as electron-linac based sources offers a new methodology for not only positron research but also for solid state physics, atomic and molecular science, biological science and other related sciences. This facility was constructed during FY2001-FY2002 [1]. In FY2003 additional radiation shields were installed and a slow positron transport line was commissioned. Preliminary experiments were made by users under Joint Development Research at High Energy Accelerator Research Organization (KEK), starting in October 2003. The facility has been available for public use since April of 2004, and five research groups are currently performing new experiments.

Site

The location of the Slow Positron Facility is shown in Appendices 1:Site and Organization (See Number 8, pp.139). The Slow Positron Facility is situated inside the Electron Linac Control Building, and the experimental hall for slow positron experiments is situated on the underground level of the same building.

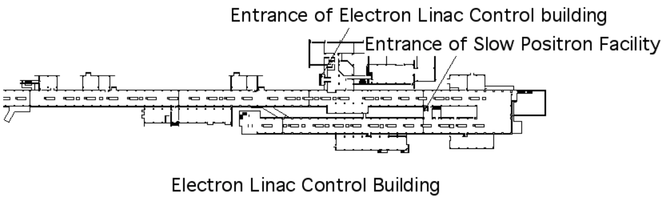

Figure 1
The site of the Slow Positron Facility.

Facility

Fig. 2 shows a plan view of the Slow Positron Facility experimental hall at the underground level of the Linac building. The next-generation slow positron generator is installed upstream of the slow positron beamline. The energetic electrons from the linac produce bremsstrahlung photons in a water-cooled tantalum target of 2-mm thickness, resulting in the pair creation of electrons and positrons. The energetic positrons are slowed down in seven sheets of tungsten converter of 25 µm thickness, which have been well annealed at 2273 K under UHV conditions. The assembly has a Wehnelt with a photochemically manufactured grid to extract slow positrons.

Table 1 Parameters of the Ps-TOF line.

Parameter	
Intensity	2×10^5 e^+/pulse
Beam energy	0.1 - 30 keV
Pulse width	22 ns (FWHM) at 5.0 keV
Repetition rate	50 Hz
Beam diameter	10 mm
Sample temperature	Room temp.
Sample potential	0 - 9.5 kV
Vacuum pressure	10^{-7} Pa

The extracted slow positrons are guided by an axial magnetic field of 60 G. Two Penning-trap electrodes separated by 7.2 m are installed in the straight section for future conversion of the pulsed beam to a dc-like beam.

At the downstream end of the beamline, a Ps-TOF spectroscopy station is installed. The parameters of the Ps-TOF line are summarized in Table 1.

A schematic diagram of the Ps-TOF experiment is shown in Fig. 3. The sample bias is varied in the range of 0~9.5 kV using a retarding electrode (RET), and the distance between the sample and the detector is adjusted by moving the sample with a linear transfer. The pulse heights and detection time of annihilation γ rays from annihilation events are recorded by a digital oscilloscope (LeCroy Wavepro 960). An example of the Ps-TOF spectrum of Al_2O_3/Al is presented in Fig. 4 where the ordinate represents pulse counts and the abscissa represents detection time relative to time zero, set by a trigger pulse from the linac. The detection of photons from 2γ annihilation events in the specimen are detected at around 80 ns, while γ rays of various energies due to the decay of traveling Ps are seen at later times.

Positronium emission from the surface is most effi-

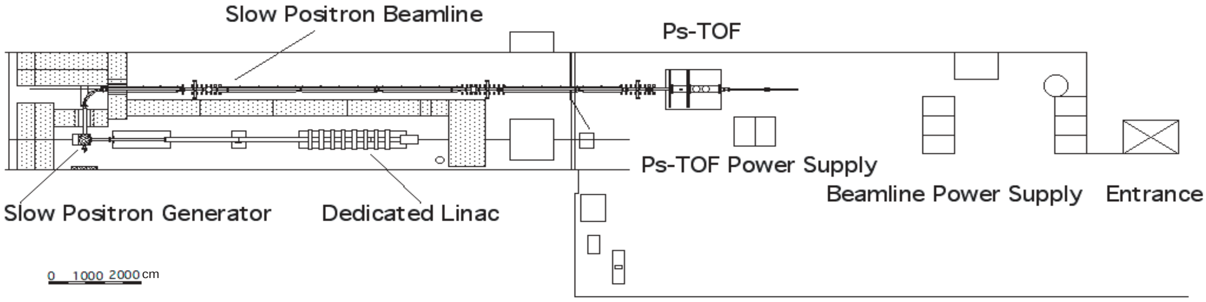

Figure 2
Schematic view of the 50MeV linac, the slow positron generator assembly, the slow positron transport line and the experimental station for positronium time-of-flight (Ps-TOF) spectroscopy.

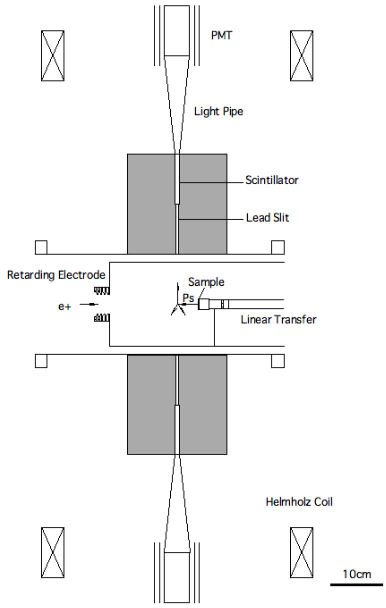

Figure 3
Ps-TOF experimental setup.

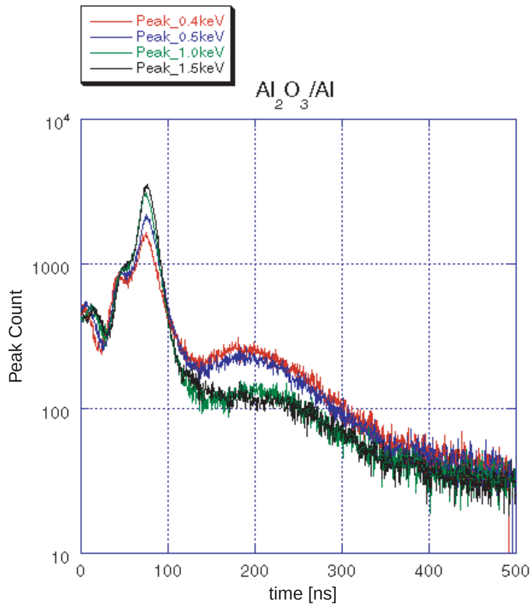

Figure 4
Obtained Ps-TOF spectra from an Al_2O_3/Al sample with different incident positron energies, ranging from 0.4 keV to 1.5 keV.

ciently detected by the implantation of a 0.4 keV positron beam (peak around 200 ns in Fig. 4). The center of the positronium emission peak appears at later times when the implantation energy of positron is increased, and the positronium yield decreases as the positron penetrates deeper through the surface. This phenomenon reveals the structure of the surface of the sample.

The dedicated Linac has been operated by the KEK Accelerator Research group and their countribution to the slow positron facility are highly appreciated. We are very grateful to Profs. Hyodo and Nagashima for their contribution in designing and construction of the Ps-TOF spectrometer.

Users and topics

We have five users groups in FY2004. These users and staff get together to promote research in the fields of Bose-Einstein condensation (BEC) effects, semiconductor industry related materials study, and R & D for positron radiography and positron imaging [2] [3].

References

[1] *Photon Factory Activity Report* **19A** (2001) 64.
[2] *Photon Factory Activity Report* **22A** (2005) 23.
[3] *Photon Factory Activity Report* **22A** (2005) 28.