A 50-MEV ELECTRON LINAC FOR THE KEK SLOW-POSITRON FACILITY

T. Shidara, I. Abe, M. Akemoto, S. Anami, A. Enomoto, S. Fukuda, K. Furukawa, H. Honma, M. Ikeda, K. Kakihara, N. Kamikubota, T. Kamitani, H. Katagiri, H. Kobayashi, T. Kuriharai, Y. Ogawa, S. Ohsawa, T. Oogoe, T. Matsumoto, S. Michizono, H. Nakajima, K. Nakao, A. Shirakawa, T. Suwada, Y. Takeuchi, S. Yamaguchi, and Y. Yan, KEK, High Energy Accelerator Research Organization, Oho, Tsukuba, Ibaraki 305-0801, Japan

Abstract

A 50-MeV electron linac is constructed as a primary beam source for the production of slow-positron beams at the KEK slow-positron facility. This linac comprises a gun, a pre-buncher, a buncher and a 4-m accelerating structure with a 40-MW klystron unit. Utilizing a 1-kW electron beam, more than one hundred million slow positrons per second will be available in various fields of solid state physics.

1 INTRODUCTION

A positron beam is a useful probe for investigating the electronic states in solids, especially concerning the surface states and defect distribution. However, such studies, as low-energy positron diffraction, positron microscopy, positron reemission microscopy and positronium spectroscopy, are very limited due to the poor intensity obtained from a conventional radioactive-isotope-based positron source. We, therefore, investigated accelerator-based slow-positron sources [1-6], and constructed the slow-positron facility [7, 8], utilizing our 2.5-GeV electron linac [9, 10] as its primary beam source.

Although we had opened this facility to slow-positron users [11,12], we had to relocate our facility to the south of our linac, relevant to the upgrade plan of the KEK 2.5-GeV linac. The upgraded linac (the KEKB linac) supplies 8-GeV electron and 3.5-GeV positron beams to the asymmetric collider KEKB [13-15]. There is a heavy competition between the KEKB and the PEPB, the KEKB linac is and will be almost fully occupied by the continuous (top-up) injection to the KEKB rings in order to achieve a possible maximum luminosity. We therefore decided to install a 50-MeV electron linac as a dedicated primary electron beam source for the KEK slow-positron facility utilizing the remnants of the KEK 2.5-GeV linac. We describe here this 50-MeV electron linac and our slow-positron facility.

2 KEK SLOW-POSITRON FACILITY

The KEK slow-positron facility consists of a 50-MeV electron linac as a primary beam source, a target-moderator assembly, a slow-positron beam-transport line and relevant assemblies. The 50-MeV linac comprises a gun, a pre-buncher, a buncher and a 4-m accelerating structure with a 40-MW klystron unit. This linac can supply a 1-kW long and a 100-W semi-long beams to the positron production target. Characteristics of the 50-MeV linac are listed in Table 1. Utilizing a 1-kW electron beam, more than one hundred million slow positrons per second will be achievable.

Table 1: Characteristics of the 50-MeV linac

	Long	**Semi-long**
Beam energy	25 MeV	50 MeV
Pulse length	2 μs	20 ns
Beam current	400 mA	2 A
Pulse repetition	50 pulses/s	50 pulses/s
Beam power	1 kW	100 W
Positron intensity	10*8 positrons/s	10*7 positrons/s

The primary electron beam is injected into the target. The extracted slow-positron beam is directed by a 10-m long beam-transport line with an axial magnetic field of 100 G to an experimental area. Several sets of steering coils were installed along the slow-positron beam-transport line in order to adjust the slow-positron beam trajectory. Penning-trap electrodes are also installed in order to make a dc beam from a pulsed beam. As for the beam monitors, micro-channel plates (MCP) for the beam profile are intensively used.

3 PRESENT STATUS

Almost all components of the 50-MeV electron linac, a target-moderator assembly and a slow-positron beam-transport line are installed. The commissioning of the 50-MeV electron linac started from this March. At the initial stage, a slightly low-power primary beam of 15 W (an energy of 40 MeV, a pulse length of 15 ns, a bunch current of 30 nC and a repetition rate of 12.5 pulses/s) was successfully accelerated and an appreciable number of slow positrons were observed by MCP which locates at the end of the 10-m slow-positron beam-transport line. Since the insufficiency of the radiation shielding was recognized during this commissioning, we are planning to reinforce the shielding in the near future.

4 FUTURE PLAN

Linac based high-intensity slow-positron beam enables us to investigate the defects mapping (two dimensional or three dimensional information of defects distribution). More intense slow-positron beam will be achievable utilizing a primary electron beam power of 5 kW by upgrading the rf source of this test linac.

5 SUMMARY

A 50-MeV electron linac is constructed as a dedicated primary beam source for the KEK Slow-Positron Facility. During its preliminary performance test, a low-power primary electron beam of 15 W was injected into the positron production target and slow-positron beams were successfully generated. After reinforcing the radiation shield, we will open this facility to slow-positron users.

6 ACKNOWLEDGMENTS

The authors are greatly indebted to the director of the Institute of Materials Structure Science, Prof. Y. Kimura as well as to the staff of the KEK administration department for their encouragement and continuous support to this slow-positron project. They also express their gratitude to Drs. M. Yoshioka, H. Hayano, S. Ban, K. Takahashi, and T. Sanami for their support and help to reinforcing the radiation shield of our 50-MeV electron linac.

7 REFERENCES

[1] R. H. Howell, R. A. Alvarez and M. Stanek, "Production of Slow Positrons with a 100-MeV Electron Linac", Appl. Phys. Lett. 40, p751 (1982).

[2] R. Ley, K. D. Niebling, A. Osipowicz, A. Picard and G. Werth, Proc. 7th Int. Conf. on Positron Annihilation, New Delhi, 1985, eds. P. C. Jain, R. M. Singru and K. P. Gopinathan (World Scientific, Singapore), p996 (1985).

[3] L. D. Hulett, Jr., T. A. Lewis, D. L. Donohue and A. Pendyala, Proc. 8th Int. Conf. on Positron Annihilation, Gent, 1988, eds. L. Dorikens-Vanpraet, M. Dorikens and D. Segers (World Scientific, Singapore), p586 (1989).

[4] T. Akahane, T. Chiba, N. Shiotani, S. Tanigawa, T. Mikado, R. Suzuki, M. Chiwaki, T. Yamazaki and T. Tomimasu, "Stretching of Slow Positron Pulses Generated with an Electron Linac", Appl. Phys. A51, p146 (1990).

[5] R. Suzuki, Y. Kobayashi, T. Mikado, H. Ohgaki, M. Chiwaki and T. Yamazaki, Proc. 9th Symp. on Accelerator Science and Technology, Tsukuba, p237 (1993).

[6] Y. Itoh, M. Hirose, S. Takamura, O. Sueoka, I. Kanazawa, K. Mashiko, A. Ichimiya, Y. Murata, S. Okada, M. Hasegawa and T. Hyodo, "Brightness Enhanced Intense Slow Positron Beam Produced using an Electron Linac", Nucl. Instr. Meth., A305, p269 (1991).

[7] A. Asami, A. Enomoto, H. Kobayashi, T. Kurihara, K. Nakahara and T. Shidara, "A Slow-Positron Source Project using the Photon Factory Electron Linac", Materials Science Forum, 105-110, p1833 (1992).

[8] T. Shidara, A. Enomoto, T. Kamitani, H. Kobayashi, T. Kurihara, A. Shirakawa, H. Hirayama, I. Kanazawa, A. Asami and K. Nakahara, "The KEK Slow-Positron Source", Materials Science Forum, 175-178, p205 (1995).

[9] J. Tanaka, "Construction of the Photon Factory 2.5 GeV Injector Electron Linac", Nucl. Instr. Meth., 177, p101 (1980).

[10] I. Sato, "Accelerator Structure and Beam Transport System for the KEK Photon Factory Injector", Nucl. Instr. Meth., 177, p91 (1980).

[11] Y. Morinaka, Y. Nagashima, Y. Nagai, T. Hyodo, T. Kurihara, T. Shidara and K. Nakahara, "Time-of-Flight Spectroscopy of Positronium Emission from SiO2 Surface", Materials Science Forum, 255-257, p689 (1997).

[12] eds. T. Shidara and K. Nakahara, "Construction Report of the PF Slow-Positron Source (II)", KEK Report, 97-12, (1997).

[13] "KEKB B-Factory Design Report", KEK Report, 95-7, (1995).

[14] eds. I. Sato, S. Anami, A. Enomoto, S. Fukuda, H. Kobayashi and K. Nakahara, "Design Report on PF Injector Upgrade for KEKB", KEK Report, 95-18, (1996).

[15] A. Enomoto, et al., Proc. of the 1993 Particle Accelerator Conference, U.S.A., 1993.