INTENSE POSITRON BEAMS: LINACS*

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SUMMARY

Beams of monoenergetic positrons with energies of a few eV to
many keV have been used in experiments in atomic physics, solid
state physics and materials science. The production of positron
beams from a new source, an electron linac, is described.

Intense, pulsed beams of low-energy positrons have been
produced by a high-energy beam from an electron linac. The
production efficiency, moderator geometry, beam spot size and other
positron beam parameters have been determined for electrons with
energies from 60 to 120 MeV. Low-energy positron beams produced
with a high-energy electron linac can be of much higher intensity
than those beams currently derived from radioactive sources. These
higher intensity beams will make possible positron experiments
previously infeasible.

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INTRODUCTION

Since the introduction of experiments using beams of mono-energetic positrons there has been a continuing effort to increase the intensity of these positron sources for both pulsed and continuous beams. These efforts have centered mainly around the improvement in the conversion of energetic positrons from radioactive sources to mono-energetic, low-energy positrons by improving the moderator material characteristics. This effort has led to higher beam intensity through improved moderator efficiency and a clearer understanding of the production of low energy positrons by a process of diffusion to the moderator surface and expulsion by the negative positron work function. The efficiency of the moderation process has been improved to such an extent that theoretical limits have been approached. Any further large increases in positron beam intensity must come from the use of more intense sources.

To provide a more intense source of positrons through radioactive decay requires the use of sources with short half lives. The limit of the positron intensity from the usual sources of positrons, $^{22}$Na or $^{58}$Co, results from the inability of the positrons from the back of the source to penetrate the source material and escape the source configuration. The overburden of material is lower in sources that have short half lives, $^{11}$C or $^{64}$Cu but these sources must be continually renewed by irradiation with an accelerator or reactor.

Intense sources of high energy positrons can be obtained by pair production in the bremsstrahlung field that results from hitting a radiator-converter with the electron beam. Positrons are produced in electron-positron showers resulting from repeated cycles of pair-production and bremsstrahlung radiation. The positrons can be moderated and emitted as low energy positrons in much the same way as in the radioactive source systems. Low energy positron beams produced by this technique have been used at other laboratories, but the beams were of low intensity. More recently work at Livermore has demonstrated that intense beams of low energy positrons can be derived from linac electron beams. Experiments performed at Mainz have also been successful in producing intense positron beams.

In the Livermore experiments the important parameters of the production of low energy positrons from high energy electrons have been identified and operating ranges established: The geometry of the electron radiator-converter and positron moderator was studied, and the optimum radiator-converter thickness was determined for both tungsten and tantalum convertors. The variation in positron production with primary electron beam energy was measured. The