DESIGN AND OPERATION OF PEGASUS THERMIONIC CATHODE

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Abstract

A new thermionic cathode has been developed and installed for use on the PEGASUS plane wave transformer injector. The novel design of the LaB_6 cathode allows for thermionic emission as well as photoinjector operation. Both test-stand measurements and in situ operational experience are reported.

INTRODUCTION

The PEGASUS (Photoelectron Generated Amplified Radiation Source) was commissioned at UCLA as a linac-based electron beam radiation laboratory [1]. The injector is a PWT (Plane Wave Transformer) originally designed to operate strictly as a photoinjector. The virtues of photocathodes are much cited. Their ability to produce short electron pulses for applications such as free electron lasers (FELs) is superior [2]. However, the operation of photocathodes is not always possible or even desirable. In fact for high average charge applications, such as planned optical transition radiation (OTR) experiments [3], a thermionic cathode becomes more desirable.

A thermionic cathode assembly was developed, tested, and installed for use in the PEGASUS PWT injector. The PEGASUS thermionic cathode assembly uses a lanthanum hexaboride (LaB_6) cathode heated by a UHV button heater. The assembly can be installed with little modification to the PWT, and it can operate as a photocathode as well as a thermionic emitter.

APPARATUS

The PEGASUS thermionic cathode is a compact and cost efficient emitter designed to provide beam charges of up to 1 nC. By virtue of its simple design, the thermionic cathode can also operate as a photocathode. The thermionic cathode assembly consists of a cylindrical LaB_6 cathode conductively heated by a UHV cartridge heater, all incased in a molybdenum body. The LaB_6 cathode is 3.5 mm in diameter, with an active area of approximately 3 mm, and 1 mm thick. The heater is a commercially available HeatWave UHV Standard Series cartridge heater rated at 1200 C at 7.5 Watts. Two versions have been constructed. A schematic of the major components of the later version is shown in Figure 1.

Test-Stand Setup

For the test-stand measurements, the thermionic cathode assembly is housed in a cylindrical holder whose geometry duplicates that of the cathode mounting plate of the PWT. The entire assembly is located within a vacuum chamber. With the cathode held at ground potential, a voltage of 2 kV is applied to a collector 3 mm from the cathode. The thermionic current is measured with an Amp meter.

PWT Installation

The PWT's design allows for insertable and removable cathodes. The thermionic cathode assembly is designed to operate as a replacement cathode without the need to modify the PWT structure. A schematic of the cathode assembly is also shown in Figure 1.

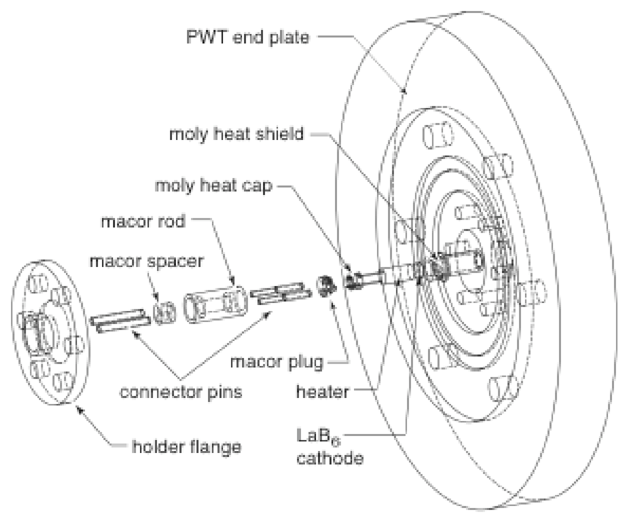

Figure 1: Schematic of thermionic cathode assembly.

EXPERIMENTAL RESULTS AND DISCUSSION

Test-Stand Measurements

With the collector bias at up to 2.0 kV and a maximum operating heater power of 12 Watts, a thermionic DC current of approximately 400 μA was measured. The temperature of the cathode was estimated at approximately 1000-1100 C. This result is consistent with published measurements of thermionic emission of LaB_6 [4]. Further enhancement, when operating under RF power (E=50 MV/m), will result in an increased Schottky Current well into the mA range.

Operational Experience

With the thermionic cathode assembly installed in the PWT, the system was evacuated and a base pressure below 10^{-9} Torr was reached. Cathode heater power was supplied by a remotely controlled power supply. The cathode was slowly heated and allowed to outgas. The temperature of the cathode was qualitatively measured by imaging the surface of the LaB_6 cathode using a mirror and camera installed on the beamline. The temperature was estimated to be 900-1000 C based on its color and intensity. Unfortunately, the small size of the cathode and its distance from the imaging mirror made measurement using our pyrometer unreliable.

The thermionic cathode assembly was RF tested to approximately 15 MW. On a number of limited runs, the cathode was brought close to emission temperature (~1000 C) and RF power was applied to the PWT. YAG crystal beam position monitors and a faraday cup were used to observed and measure operation. Initial results indicate that the LaB_6 cathode is not emitting as expected. The problem is likely the result of the cathode not reaching emission temperature. This was in part due to the heater losing contact with the LaB_6 cathode caused by repeated heating and cooling cycles. A new assembly was designed and constructed to address this problem. Further testing in currently underway.

ACKNOWLEDGEMENTS

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