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THE OPERATION OF THE BNL/ATF GUN-IV PHOTOCATHODE RF GUN AT THE ADVANCED PHOTON SOURCE*

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Abstract

At the Advanced Photon Source (APS) at Argonne National Laboratory (ANL), a free-electron laser (FEL) based on the self-amplified spontaneous emission (SASE) process is nearing completion. Recently, an rf photoinjector gun system was made available to the APS by Brookhaven National Laboratory/Accelerator Test Facility (BNL/ATF). It will be used to provide the high-brightness, low-emittance, and low-energy spread electron beam required by the SASE FEL theory. A Nd:Glass laser system, capable of producing a maximum of 500 μJ of UV in a 1-10 ps pulse at up to a 10-Hz repetition rate, serves as the photoinjector's drive laser. Here, the design, commissioning, and integration of this gun with the APS will be discussed.

1 INTRODUCTION

The Advanced Photon Source (APS) at Argonne National Laboratory (ANL) is currently commissioning a free-electron laser (FEL) based on the self-amplified spontaneous emission (SASE) process [1]. This project, referred to as the APS SASE FEL, is designed to achieve saturation in the visible, UV, and ultimately VUV wavelengths. To assist in producing the beam required for saturation in the shortest possible distance, the APS has installed an on-loan copy of the Brookhaven National Laboratory/Accelerator Test Facility (BNL/ATF) high-brightness photoinjector, GUN-IV, at the head of its linac. This paper will discuss the gun design, drive-laser, integration with the APS systems, commissioning, and future plans.

2 DESIGN AND CAPABILITIES

The BNL-ATF 1.6-cell 2856-MHz photocathode rf gun and emittance compensation solenoid magnet is capable of producing a beam that fits design constraints of the APS SASE FEL. The fully symmetrized, π-mode device can achieve gradients of up to ~140 MV/m, capable of accelerating electrons up to 6 MeV. The solenoidal field is used to control transverse emittance dilution. The photoinjector is capable of running at repetition rates of up to 50 Hz.

3 THE APS DRIVE LASER

The drive-laser system consists of a mode-locked, diode-pumped Nd:Glass oscillator coupled to a Nd:Glass regenerative amplifier. The 119-MHz oscillator can produce 260 fs FWHM bandwidth-limited pulses centered at 1053 nm. The repetition rate of the oscillator is the 24th subharmonic of the accelerating field. The oscillator average output power is approximately 100 mW and is timing stabilized to < 1 ps rms. The regenerative amplifier is capable of producing 5 mJ in the IR and, after frequency quadrupling, ~500 μJ in the UV. During the amplification, some bandwidth is lost; therefore, the shortest pulse produced by the amplifier is roughly 1.5 ps FWHM. This is sufficiently short, based on the requirements of the photoinjector, and can be easily lengthened if so desired. The amplifier is capable of operating at up to 5 Hz, with a best effort repetition rate of 10 Hz. .

4 PHOTOINJECTOR SYSTEM

Figure 1 shows the layout of the photoinjector at the APS. A copper cathode is used, since the energy output of the drive laser is capable of producing sufficient quantum efficiency with this metal. In addition, copper will reduce the amount of time dedicated to laser cleaning and cathode replacement, and, since it is robust compared to other commonly used cathode materials, such as yttrium (Y) and magnesium (Mg), will also reduce the risk of cathode damage. The gun is driven by the UV laser beam at near normal incidence from an input mirror just after the solenoid magnet as opposed to the more difficult 70° incidence through two available laser ports. This input mirror is mounted on a rotatable *in vacuo*, micrometer, which provides the vertical positioning of the mirror as well as the horizontal positioning of the laser.

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