LOW EMITTANCE INJECTOR DEVELOPMENT FOR THE PAL-XFEL PROJECT*

J.-H. Han†, J. Hong, I. Hwang, M. S. Chae, S.-J. Park, H.-S. Kang, I. S. Ko,
Pohang Accelerator Laboratory (PAL), Pohang, 790-784, Republic of Korea

Abstract

An injector for low emittance electron beam generation as well as high repetition rate and more reliable operation is under development at PAL. Here, we introduce the design of the S-band photocathode gun using a coaxial coupler for the PAL-XFEL project. The gun will be able to provide a low emittance electron beam for ultimate X-ray FEL performance. Injector beam dynamics optimization using this gun is shown. Various injector operating conditions are studied numerically.

INTRODUCTION

The Pohang Accelerator Laboratory X-ray Free electron Laser (PAL-XFEL) project [1] started in 2011. This project aims at the generation of X-ray FEL radiation in the range of 0.1 to 10 nm for users. The machine consists of a 10 GeV linear accelerator and soft and hard X-ray undulator beamlines. The accelerator will operate at a repetition rate of 60 Hz. Building construction starts in September 2012.

The PAL-XFEL baseline injector [2] was designed for satisfying the PAL-XFEL beam requirements. The baseline injector adopts the GTF gun [3, 4] developed at PAL over the last six years and two 3 m long S-band travelingwave tubes. The injector has been installed in the Injector Test Facility (ITF) and first beam generation is foreseen in September 2012. RF conditioning of the gun cavity and accelerator tubes is being started. Numerical simulations using the baseline injector shows 0.26 mm mrad normalized transverse rms emittance at 200 pC are achievable [2]. The experimental target is 0.4 mm mrad as first phase. For emittance measurements, three quadrupole magnets and a screen will be used [5].

Transverse emittance of an electron beam has a crucial role in hard X-ray SASE FEL. For the PAL-XFEL hard X-ray case, a 50% emittance reduction will result in 30 to 50% FEL power increase as well as 20 to 50% FEL saturation length reduction depending on other parameters [6]. Even though the baseline injector will fully satisfy the PAL-XFEL beam parameter, a low emittance injector will allow better FEL performance with reduced undulator length.

The low emittance injector has two major changes compared with the baseline injector. The RF gun with a side coupler is replace with a gun with coaxial coupler. Three accelerator tubes will be used for acceleration instead of two tubes in the baseline injector. Possible future installation of the low emittance injector in the PAL-XFEL main linac will be also discussed.

* Work supported by The Ministry of Education, Science and Technology of the Korean Government

† janghui_han@postech.ac.kr

LOW EMITTANCE GUN

The PAL-XFEL low emittance gun is similar as the Diamond S-band (2.998 GHz) gun which was developed for high repetition rate operation and low emittance beam generation [7]. By adopting a coaxial RF coupler connected at the gun exit as for the DESY PITZ gun [8], the gun solenoid can be positioned at an optimum location for low emittance and cooling water channels can fully surround the gun cavity cylinder for maximizing cooling capacity and allowing uniform temperature distribution over the gun body. With an exchangeable photocathode plug, high quantum efficiency cathodes can be used for reducing drive-laser power requirement and a damaged cathode can be easily replaced with a fresh one under ultra-high vacuum. Since the PAL-XFEL gun should operate at 2.856 GHz, the Diamond gun cavity was enlarged by about 5% and cooling channel was adjusted. The first technical design is ready.

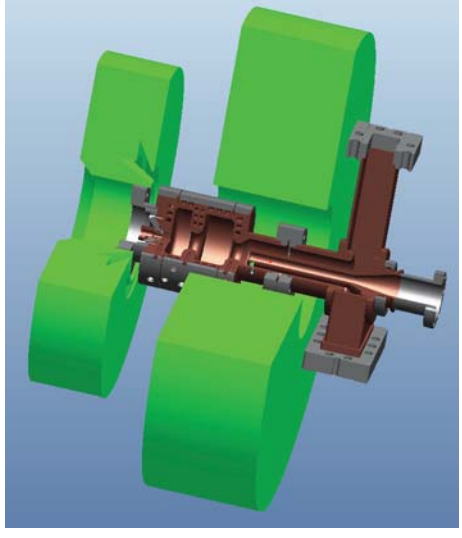

Figure 1: Low emittance gun cavity and solenoids. A cathode exchange system is connected at the rear of the gun.

In this gun design, the center of the solenoid is at 0.105 m from the cathode. For magnetic field compensation at the cathode, a bucking solenoid is placed immediate upstream of the gun.

Maximum repetition rate required for the PAL-XFEL gun is 120 Hz even considering future upgrade [1]. At the first gun design, no RF pick-up probed was included as for

ISBN 978-3-95450-123-6