

Preliminary Design of a Beamline for Semiconductor Radiation Hardness Testing at KOMAC

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1. Introduction

The assessment of semiconductor characteristics in response to radiation is a critical function performed in many proton beam facilities. The National Aeronautics and Space Administration (NASA) conducts radiation tolerance tests for space and aviation components, similar to efforts by the European Space Agency (ESA) and Japan Aerospace Exploration Agency (JAXA). These organizations operate independently or collaboratively utilize global facilities to perform these essential tests. Korea Multipurpose Accelerator Complex (KOMAC) has been operating a low-flux beamline for radiation test on semiconductors, which has accreditation for JESD89B standard testing. Despite this, the existing shared use of the beamline limits its availability to domestic users and users from other application fields. At KOMAC, a new beamline is planned to be built for radiation hardness test on semiconductors. In this paper, we show a preliminary design of a beamline for semiconductor radiation hardness testing at KOMAC.

2. Beamline Design

The new beamline for the semiconductor radiation hardness testing is a beamline connecting to TR104 in the one of the 100 MeV beamlines, shown in Fig. 1. The new beamline consists of a collimator, beam optics for making uniform beam profiles and several beam diagnostics. We will be installing a collimator to reduce beam flux to 1/10,000. A graphite collimator with a 5 mm dia. aperture will cut down the beam intensity. Most of the beam power will be dissipated in the collimator. A set of two octupole magnets and a quadrupole magnet will be installed for transforming a gaussian beam into a flat top profile beam. We plan to install beam diagnostics such as an AC Current Transformer (ACCT), a stripline-type Beam Position Monitor (BPM) and a faraday cup in the beamline. Additionally, a 2D array ionization chamber will be

installed at the target position for measuring a transverse beam profile. In this section, we present design specification and simulation results satisfying our design goals.

2.1 Design Specifications

We aim to produce a beam of 100 mm × 100 mm with uniformity better than ±10 %. The design specifications are summarized in Table 1.

Table I: Key design specification of the new beamline for semiconductor radiation hardness testing at KOMAC

Parameter	Design value
Beam Energy at target	33 MeV ~ 100 MeV
Max. average power at collimator	800 W
Max. average beam current at target	10 nA
Beam size at target	100 mm × 100 mm
Beam uniformity at target	±10 %

After passing through the collimator in the new beamline and broadening into a flat beam profile, the beam intensity can be as low as 10^5 protons/cm² per pulse.

The diameter of the penetration pipe between the beamline and the target room is 180 mm. To satisfy the design specifications given in Table 1 with the narrower penetration pipe compared to the low-flux beamline (i.e. the beamline to TR102), we have re-positioned the beam optics.

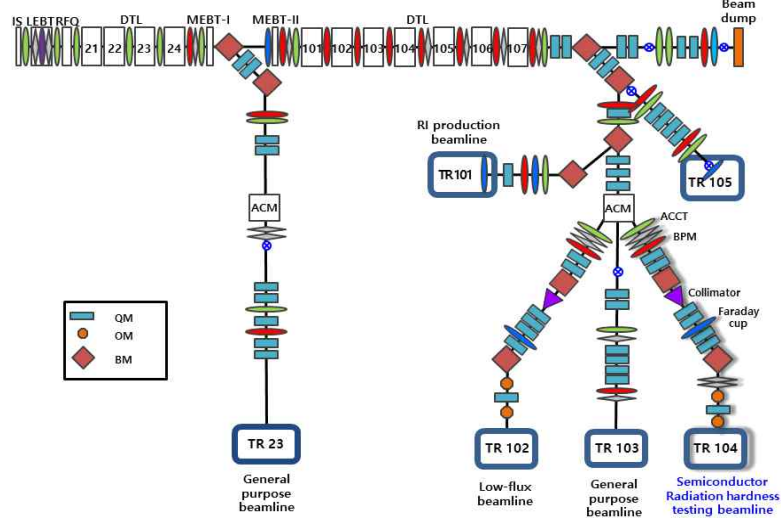


Fig. 1. The schematic of the new beamline for semiconductor radiation hardness testing at KOMAC

2.2 Design Simulation Results

Simulation is from the collimator to the target position in TR104. Input beam parameter used in the simulation is given in Table 2.

Table 2. Input beam parameter used in the simulation

Beam Parameter	x, y
rms norm. emittance	$0.225 \pi \text{ mm mrad}$
α	0
β	$13.3 \text{ mm}/\pi \text{ mrad}$

The beam profile should be spread as much as possible while passing through the penetration pipe with minimum beam losses. Last three optics, i.e. octupole-quadrupole-octupole magnet, are moved towards the wall and distance between them are fine-tuned to maximize the beam size and the uniformity. The result of envelope calculation is shown in Fig. 2.

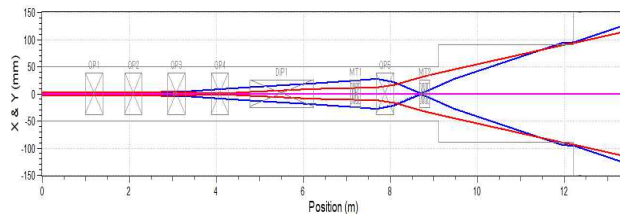


Fig. 2. The envelope calculation from the collimator to the target position in TR104

The beam distribution at the target is shown in Fig. 3. In the right bottom plot of Fig. 3, we marked a red square of $100 \text{ mm} \times 100 \text{ mm}$ to show that the simulation result showed a beam area much larger than the design goal.

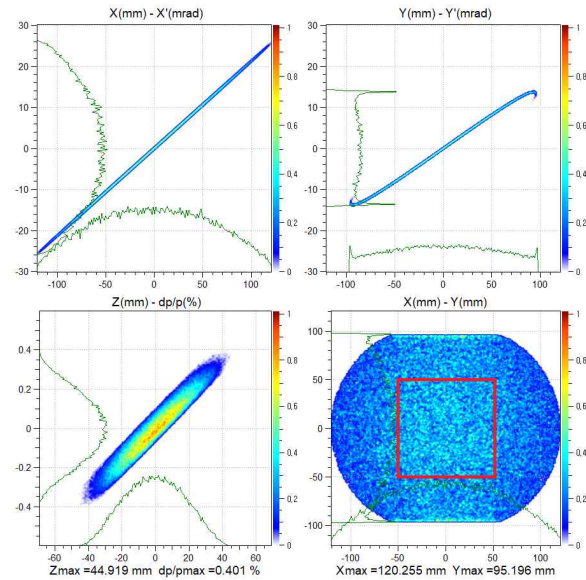


Fig. 3. The beam distribution of the new beamline at the target position

3. Conclusions

The new beamline for the semiconductor radiation hardness testing at KOMAC is introduced. The preliminary beamline design goals are set. And its simulations were performed to achieve the goals. The simulation results showed that with the new optics position, we can get the beam size larger than the design goal of $100 \text{ mm} \times 100 \text{ mm}$ with uniformity better than $\pm 10 \%$. Once the beamline is constructed, we expect that it to alleviate the demand for beamtime from semiconductor industry.

REFERENCES

- [1] J.-H. Jang, H.-J. Kwon and Y.-S. Cho, J. Kor. Phys. Soc. 59, 604 (2011)
- [2] S.-P. Yun, H.-J. Kwon, H.-S. Kim, S.-G. Lee, C. Kim, Y.-G. Song and D.-I. Kim, MOPIK038, Proc. IPAC2017 (2017)
- [3] Y.-M. Kim, S.-P. Yun, H.-S. Kim and H.-J. Kwon, Nucl. Instrum. Methods Phys. Res. A 950, 162971 (2020)
- [4] Y. Yuri, N. Miyawaki, T. Kamiya, W. Yokota and K. Arkawa, Phys. Rev. Accel. Beams 10, 104001 (2007)
- [5] S.-I. Meigo et. al, Phys. Rev. Accel. Beams 23, 062802 (2020)
- [6] D. Uriot and N. Pichoff, TraceWin user manual, CEA Saclay <http://irfu.cea.fr/dacm/logiciels/>
- [7] H.-J. Kwon, S. Lee, H.-S. Kim, J.-J. Dang, D.-H. Kim and S.-P. Yun, Error Analysis of the Low Flux Beam Line at KOMAC, KNS Autumn Meeting 2022
- [8] E. Urakabe et. al, Jpn J. Appl. Phys 38 6145 (1999)
- [9] N. Tsoupas et. al, Phys. Rev. Accel. Beams 10, 024701 (2007)
- [10] Y. Yuri, T. Ishizaka, T. Yuyama, I. Ishibori and S. Okumura, Proceeding of IPAC'10, Kyoto, Japan