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Simulation studies for Optimization of 60 MHz Rod Type Radio Frequency Quadrupole Accelerator Design at IPR

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A 60 MHz Rod type Radio Frequency Quadrupole Accelerator has been designed for material studies through Ion Irradiation at Institute For Plasma Research, Gandhinagar. Ion Irradiation has been preferred for characterization of fusion research material properties due to its inherited advantages of 1) absence of high residual radioactivity 2) well defined energy, dose rate and temperature values 3) its potential for well controlled experiments along with the fact that it rarely requires more than several tens of hours to reach damage levels of 1-100 dpa range. RFQ is chosen as front end accelerator in almost all accelerators these days as it can accelerate, bunch and focus the beam simultaneously. The accelerated ion beam produced by RFQ and the subsequent reaction of the beam with different targets is used to study (a) Radiation enhanced segregation (b) Irradiated micro-structure (c) Radiation hardening (d) Irradiation assisted stress corrosion cracking in materials. For Ion-Irradiation, ion beam generated by an Electron Cyclotron Resonance (ECR) ion (H+) source coupled to (copper) Rod type Radio Frequency Quadrupole (RFQ) Accelerator through a LEBT will be accelearted to 1 MeV at 60 MHz. Usually, high current RFQ are vane type RFQ's that are designed at higher frequencies of few hundred of MHz due to their advantage of reduced RFQ length for particular energy gain and higher shunt impedance and quality factor. But their machining is very difficult as well as they have disadvantage of presence of detrimental dipole modes. At IPR, it has been decided to use the indigenously developed RF source (35-65 MHz frequency @ 1 MW power) and design a Rod Type RFQ @ 60 MHz RF frequency to obtain the required energy gain. Design considerations involve special emphasis on reduction of beam instabilities by keeping zero-current phase advance <90 degree in longitudinal as well as transverse direction, reduction of space charge effects by avoiding resonance condition along with other considerations. Detailed beam dynamic design of 60 MHz Rod Type RFQ for hydrogen beam is carried out and a 4.2 m long RFQ comprising of 97 cells is designed after optimizing various parameters. A resonating frequency of 59.6 MHz has been achieved with 12 posts.

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