Preliminary Design of 13MHz RF Implanter 2nd Cavity

Sung-Su Cha[a.b], Hyeok-Jung Kwon[a] , Ji-Ho Jang[a], Han-Sung Kim[a], Kyung-Tae Seol[a], Yong-Sub Cho[a]
[a]*Proton Engineering Frontier Project, KAERI, DAEJEON, KOREA*
[b]*University of Science and Technology, DAEJEON,KOREA*
**Corresponding author: sscha@kaeri.re.kr*

1. Introduction

A 13MHz Radio Frequency(RF) cavity for an RF implanter has been designed and fabricated at the Proton Engineering Frontier Project(PEFP). The implanter consists of an ion source, a focusing magnet, an RF cavity, a bending magnet and a diagnostic chamber. Nowadays, inductors can be found in almost every electrical and electronic product. These key components are needed to store electrical energy, select frequencies, and protect against overvoltage and overcurrent. In the case of the inductors, which usually work in the range of radio frequency, the one of the most important attributes is the quality factor[1]. 13MHz RF implanter cavity consists of a coil having a circular cross-section, accelerating electrodes that are directly coupled to the beginning and the end of the coil, and a ground electrode for the inductor[2]. It is purpose of this paper for achieve more high beam energy to explain preliminary design concept 2nd cavity.

2. 13MHz RF Implanter System

In this section, we introduce the overall system and design specifications of 13MHz implanter[3].

2.1 13MHz RF Implanter System

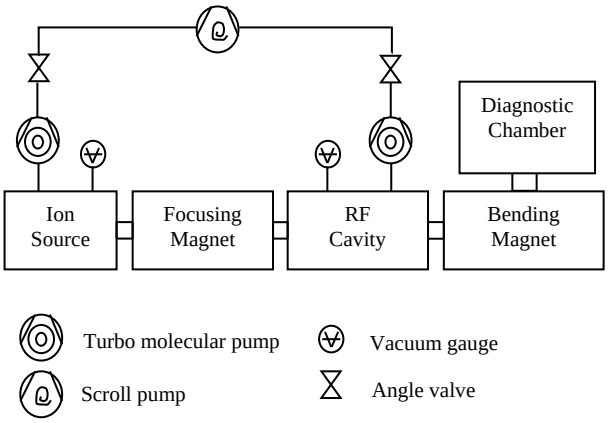

Fig. 1. 13MHz RF implanter system

Fig. 1 shows that 13MHz RF implanter system. This system consists of an ion source, a focusing magnet, an RF cavity, a bending magnet, and a diagnostic chamber.

2.2 Revision of 13MHz RF Implanter System

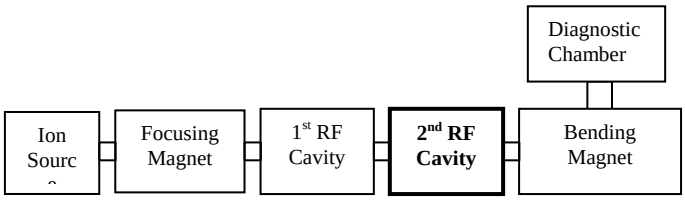

Fig. 2. Future plan- Include 2nd Cavity of 13MHz RF implanter

Fig . 2 is future development plan of RF implanter system that attach 2nd cavity from last implanter. This implanter final beam energy more high than last one and have three electrode, four gap between cavity inner wall and electrode to electrode.

3. Design concept of the 2nd cavity

3.1 Cavity Geometry Design

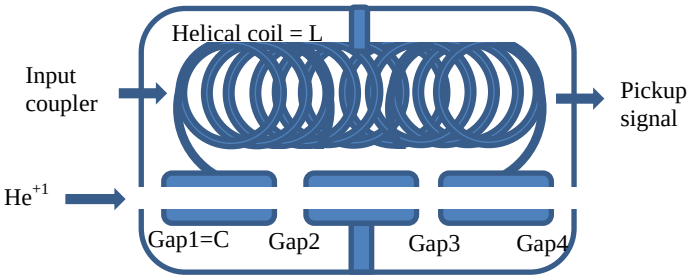

Fig. 3. Design of RF coil and electrode

Fig. 3 shows that prototype concept of 2nd cavity. It consists of an inductive coil having a circular cross section, accelerating electrodes that are directly coupled to the beginning and the end of the inductor and a ground electrode for the inductor. Each electrode is separated by gaps where the particles gain energy while passing the gaps.

3.2 Helical Coil Design

For calculation inductance[4] we may adopt Nagaoka's formula[5], which bases the calculation on the well-known formula for the inductance of a cylindrical current. Nagaoka's formula is

$$L = 0.002\pi^2 a\left(\frac{2a}{b}\right)N^2K \qquad (1)$$

In which, N is the winding density in turns per centimeter of axial length and K is the factor that takes account of the effect of the ends. Nagaoka gave a value of K as a function of the shape ratio $\frac{2a}{b} = \frac{diameter}{length(L)}$. It is better to derive K directly from the following series formula:

$$K = \frac{2\beta}{\pi}\left[\left(\log_e\frac{4}{\beta} - \frac{1}{2}\right) + \frac{\beta^2}{8}\left(\log_e\frac{4}{\beta} + \frac{1}{8}\right) - \frac{\beta^4}{64}\left(\log_e\frac{4}{\beta} - \frac{2}{3}\right) + 5\frac{\beta^6}{1024}\left(\log_e\frac{4}{\beta} - \frac{109}{120}\right) - \cdots\right] \quad (2)$$

, in which β is $\frac{b}{2a}$. This case K is 0.6415, inductance is 15.16uH. Resonance frequency and capacitance are 13MHz, 9.8pF respectively.

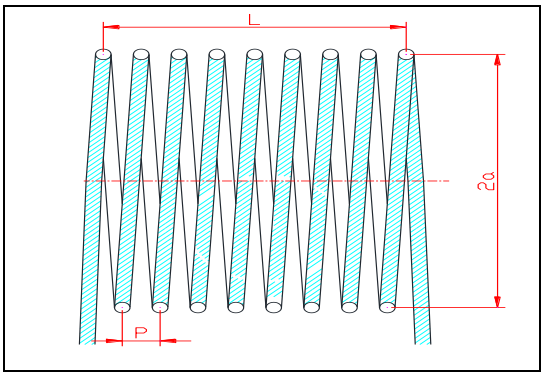

Fig. 4. The model of the inductor

Fig. 4 shows that further research 2nd cavity helical coil preliminary design concept

4. Conclusions

In this paper, the design concept of 13MHz RF implanter 2nd cavity considered. A resonant frequency of implanter was obtained 1st and 2nd cavity same from 13MHz. Further consideration will be done in near future that is coupling loop diameter of input coupler, electrode length, synchronous phase(-30°) and between 1st and 2nd cavity gap length.

ACKNOWLEDGEMENTS

This work is supported by the Ministry of Education, Science and Technology of the Korean Government

REFERENCES

[1] Zoltán PÓ LIK, Miklós KUCZMANN, Examination and Development of a Radio Frequency Inductor, Széchenyi István University
[2] T. A. Trinh, Y. S. Cho, H. J. Kwon, J. H. Jang, H. S. Kim, B. S. Park, K. T. Seol, D. I. Kim, Design and Measurement of the RF Properties of a 13MHz Cavity for the RF Implanter. Journal of Korean Physical Society, Vol.59, No. 2, August 2011, pp. 599~603.
[3]S.S Cha, H.J Kwon, J. H Jang, H. S Kim, Y. S Cho, 13.56MHz RF Implanter Vacuum System, Korean nuclear society.2011.
[4]Frederick W. Grover, INDUCTANCE CALCULATIONS, p.142~162.
[5]Nagaoka, Jour. Coll. Sci. Tokyo 27, 18-33, art. 6(1909); B. of S. Sci. Paper 169, 119-121.