Optimized Design of Split-ring Type of Micro-strip line Resonator

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POSTECH

Abstract

Recently, micro-plasma source, owing to portability and low cost, is used in various areas such as bio-MEMS, small-scale materials processing and micro-chemical analysis systems. However, previous line type micro-strip has been faced with some problem like the amount of power and vacuum levels. F. Iza et al. proposed split-ring type micro-strip line device at 900 MHz and measured plasma parameters. In this paper, the way to improve power efficiency of split-ring type micro-strip line is proposed considering various design parameters, especially operation frequency and quality factor. From the simulation studies, the optimum design results at 2.45 GHz is also described in this paper. Following from this optimized design, split-ring type micro-strip device can be prepared, so the plasma density and temperature will be able to be measured.

Contents

- Introduction
- Description of MSRR
- Principle of Operation
- Transmission Line Theory
- Results
- Conclusion
- Future Research

Introduction

MSRR

Micro-strip Split Ring Resonator

GOAL

Impedance-matched low loss device

Optimization of geometry

Operation at atmospheric pressure

Low power-low voltage : Application of portable device

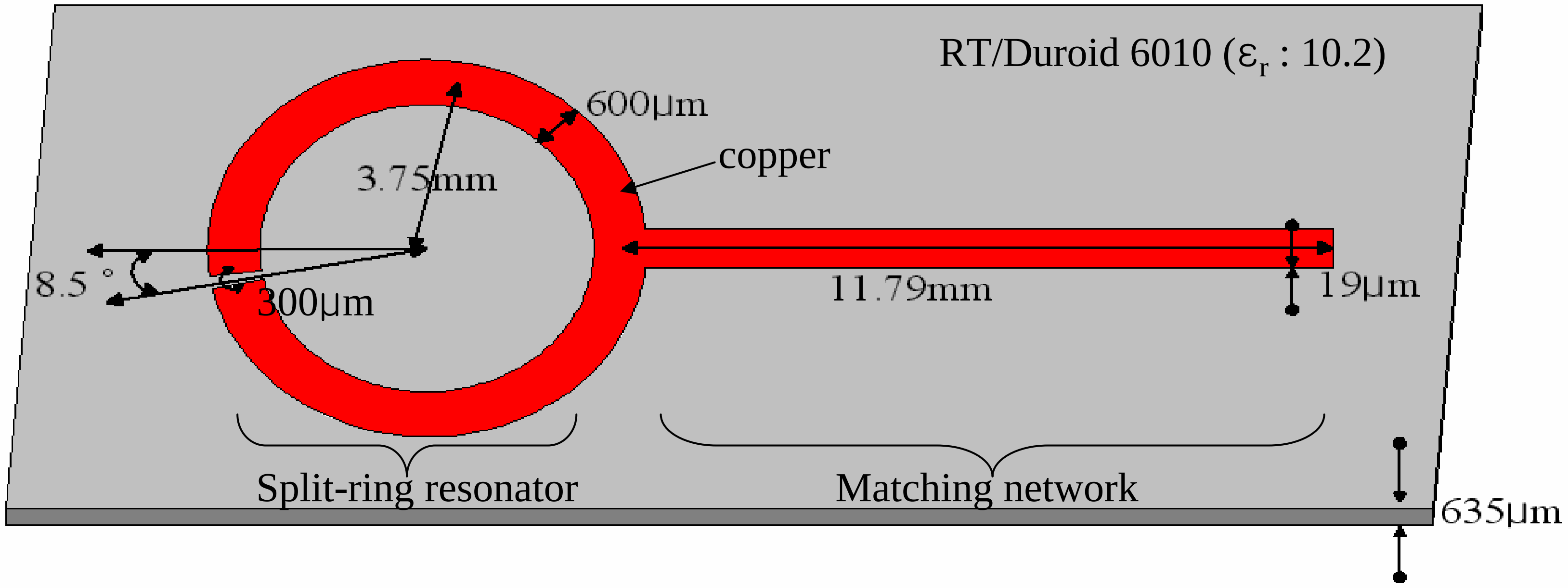
APPLICATION

Bio-MEMS

Small scale material processing

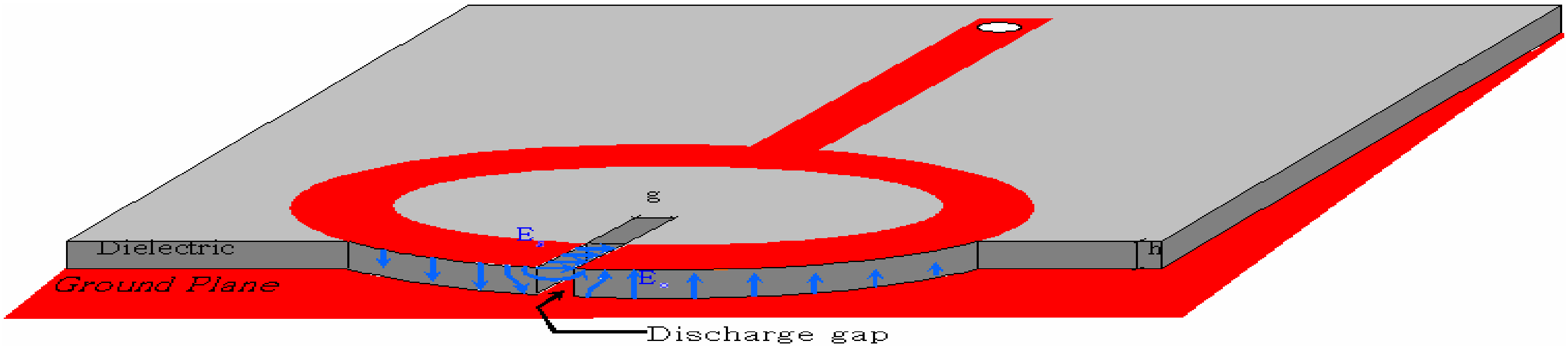
micro-chemical analysis systems

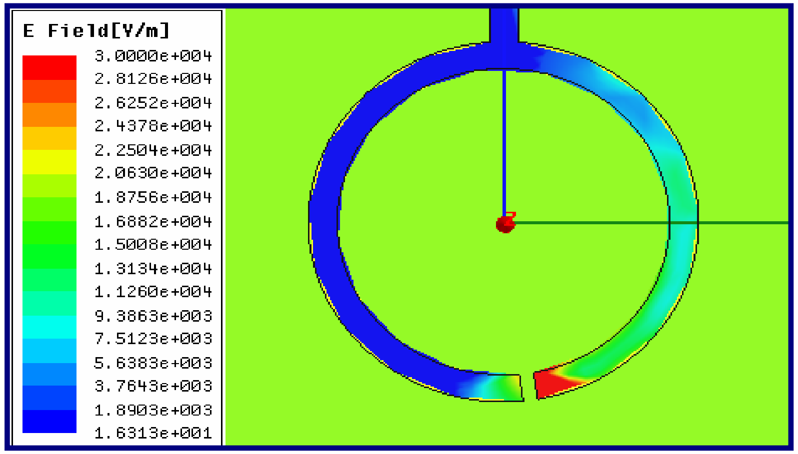
Description of the MSRR



- Circumference of the split-ring resonator is half wavelength.
- Length of matching network is quarter wavelength.
- High permittivity of the dielectric and ring geometry affect compact system.

Principle of Operation



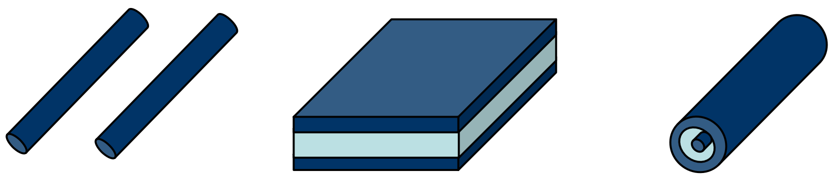


HFSS-Plot E field

- The electric field concentration at the gap.
  - 1st odd mode
  - high dielectric constant substrate is used
- Near the gap, the field jumps directly from one end of the ring to the other.
  - Electric field vector changes both direction and magnitude.
  - Eg ~ 2｜Eo｜h/g

Transmission Line Theory

Type



Two-wire Parallel-plate Coaxial

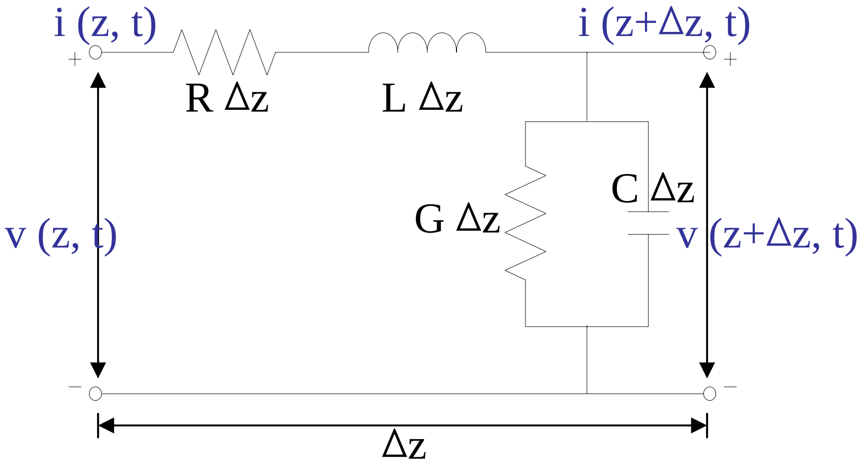
GENERAL EQUATION

$$\frac{d^2V(z)}{dz^2} = \gamma^2 V(z)$$

$$\frac{d^2I(z)}{dz^2} = \gamma^2 I(z)$$

$$where, \gamma = \alpha + j\beta = \sqrt{(R + j\omega L)(G + j\omega C)}$$

EQUIVALENT CIRCUIT



R, resistance per unit length

L, inductance per unit length

G, conductance per unit length

C, capacitance per unit length

Transmission Line Theory (cont'd)

PARAMETERS

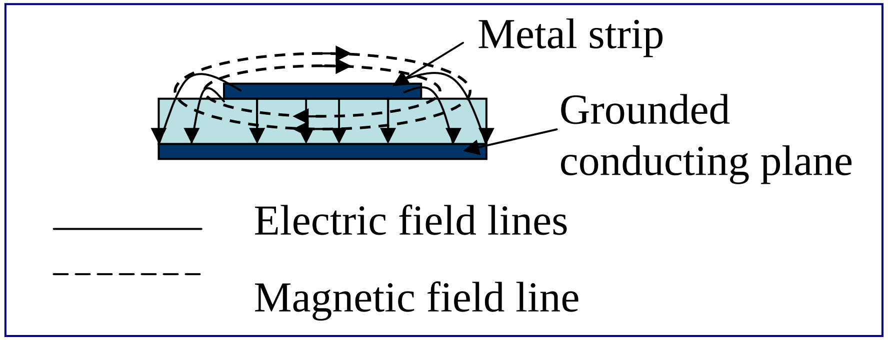
Parallel-plate line, called micro-strip line or strip-line.

$$C = \varepsilon \frac{W}{d}$$

$$L = \mu \frac{d}{W}$$

$$G = \sigma \frac{W}{d}$$

$$R = \frac{2}{W}\sqrt{\frac{\pi f \mu_c}{\sigma_c}}$$



CARACTER -ISTIC

$$V(z) = V_0^+ e^{-\gamma z} + V_0^- e^{\gamma z}$$

$$I(z) = I_0^+ e^{-\gamma z} + I_0^- e^{\gamma z}$$

$$Z_0 = \frac{V_0^+}{I_0^+} = -\frac{V_0^-}{I_0^-}$$

$$Z(z') = Z_0 \frac{Z_L + Z_0 \tanh \gamma z'}{Z_0 + Z_L \tanh \gamma z'}$$

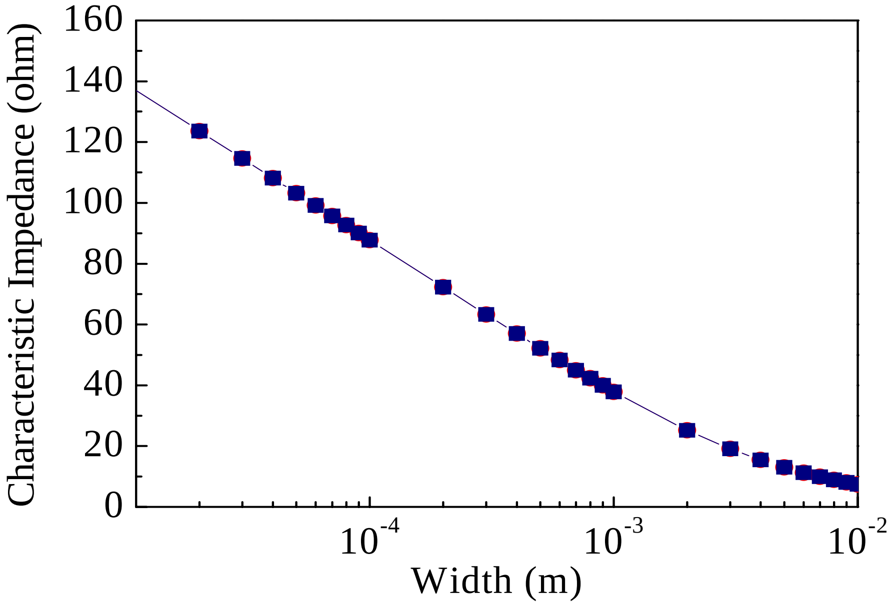
$$Z_{in} = (Z)_{z'=l} = Z_0 \frac{Z_L + Z_0 \tanh l}{Z_0 + Z_L \tanh l}$$

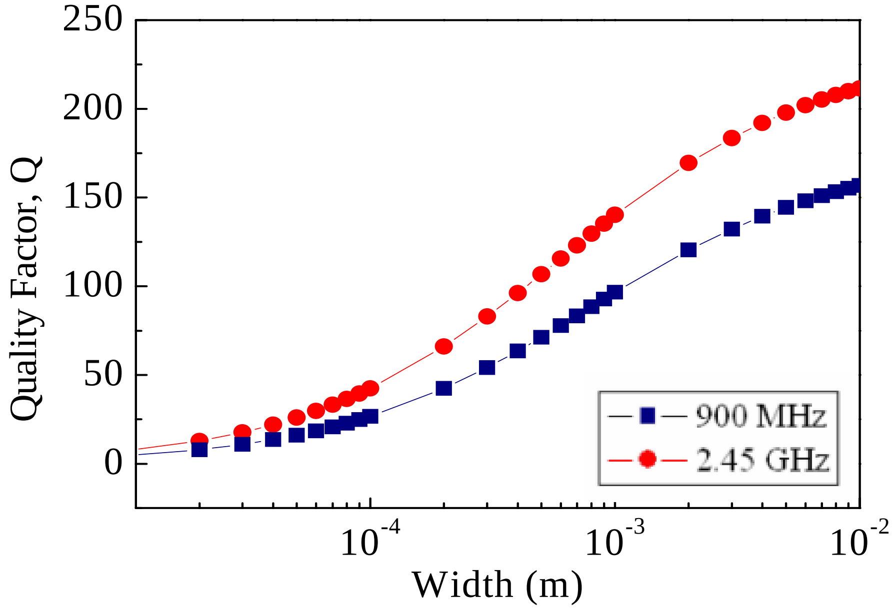
where, Z_0 : characteristic impedance

Z_{in} : input impedance

Results

ELECTRICAL PARAMETERS

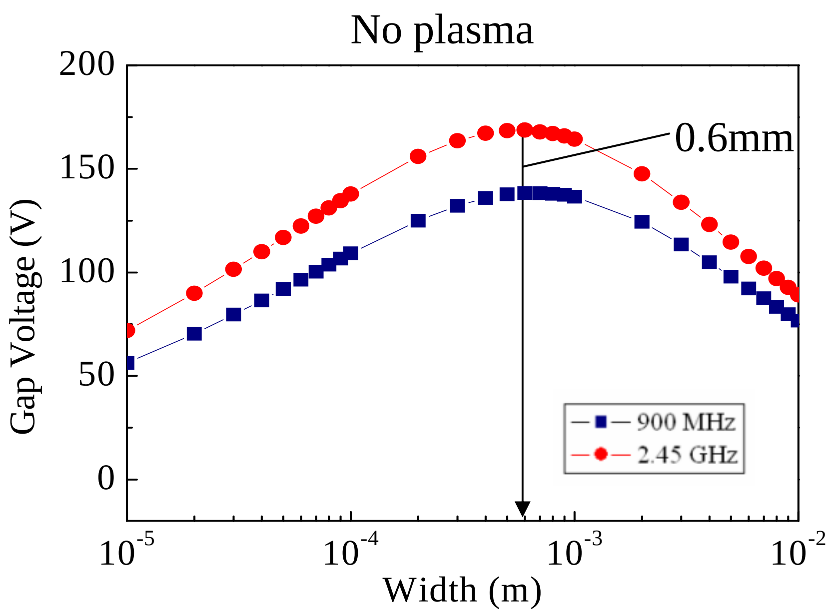


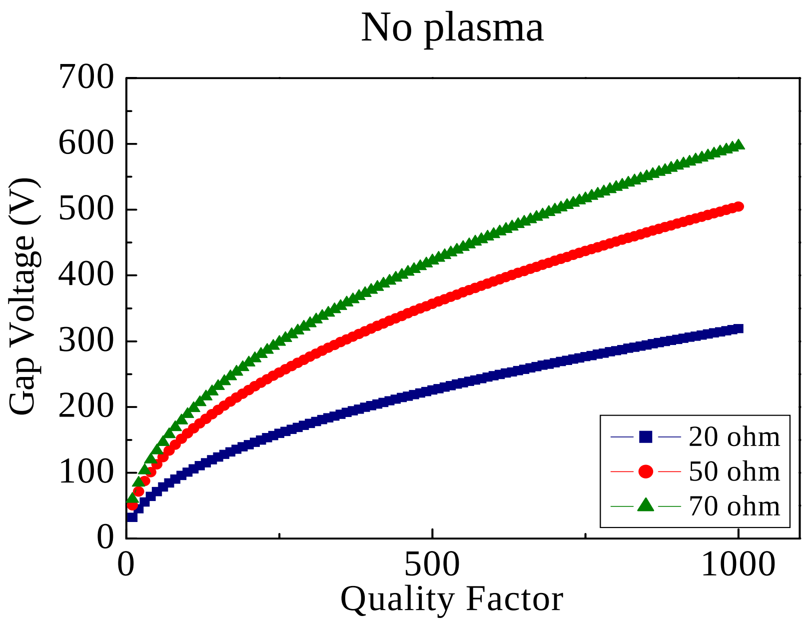


- Characteristic impedance decreases with increasing width.
- Quality factor increases with increasing width.

Results (cont'd)

GAP VOLTAGE



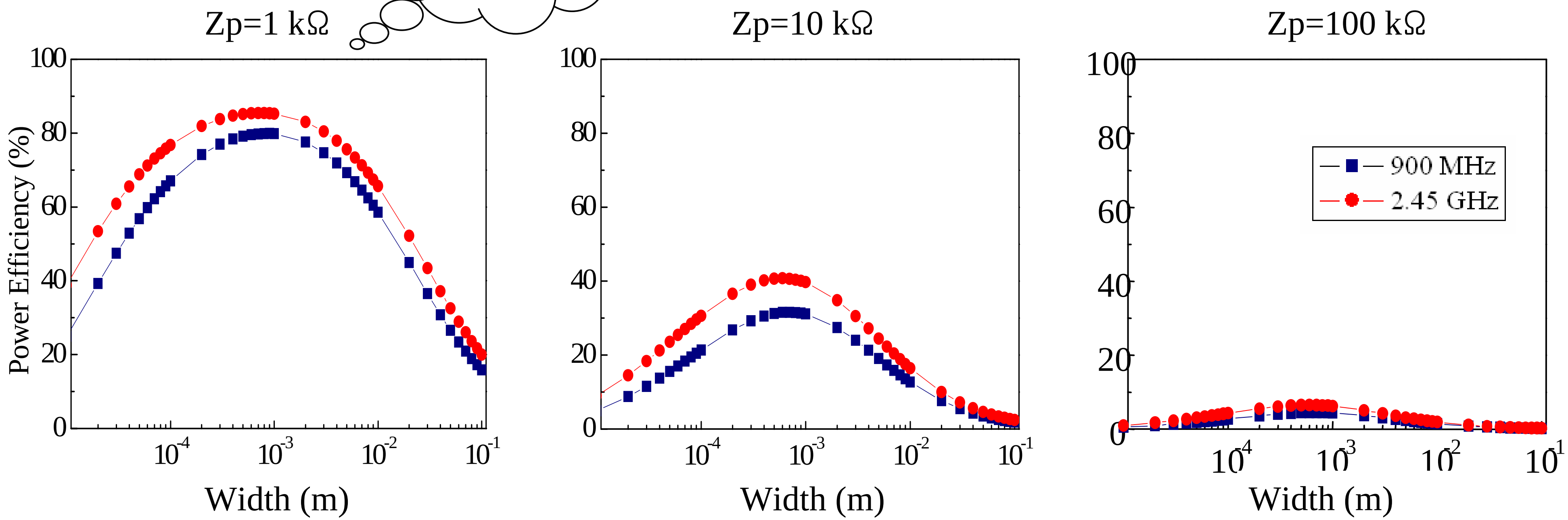


▪ It can be noticed that an increment in operating frequency from 900MHz up to 2.45GHz increases the gap voltage by ~10% during the ignition of the discharge.

Results (cont'd)

POWER EFFICIENT

Optimum line width can be found!!



- Power efficiency, η

η = power dissipated in the plasma/power dissipated in the device

- η is reduced not only in narrow width but also in wide width because of low Q factor and low characteristic impedance respectively.

Conclusion and Future Research

CONCLUSION

- In order to optimize the normalized plasma impedance, high-impedance micro-strip lines, i.e. narrow lines, are desirable.
- However, reducing the width of the line increases the conductor losses.
- The optimal line width is decided from the results of calculated power efficiency and gap voltage as a function of line width.
- The optimum line width is 0.6 mm. (At 2.45GHz)

FUTURE RESEARCH

- Fabrication of device.
 - Photolithography, wet etching
- Measurement of plasma characteristics.
 - Measurement of electron density using micro-size probe.
 - Measurement of electron/gas temperature using OES method.