§7. Development of Polarizers Optimized for Low Ohmic Loss and any Polarization State in ECRH

Tsujimura, T.I., Idei, H. (Kyushu Univ.), Kubo, S., Kobayashi, S.

Effective power absorption of an electron cyclotron wave into a plasma requires an appropriate setting of polarization. The desired polarization can be achieved by grating polarizers installed at miterbends in a transmission line. In megawatt cw transmission lines, the polarizer must satisfy highly efficient coverage of any polarization states, high-power tolerance, and low-loss features. In the last fiscal year, polarizers optimized for any polarization state were successfully realized.[1] In this fiscal year, polarizers optimized not only for any polarization state but also for low ohmic loss were successfully designed and fabricated.

In order to evaluate the ohmic loss on the groove surface of a polarizer, the polarizer on a miterbend is simulated using the commercial COMSOL Multiphysics® with an rf solver. Figure 1 shows a simulation result of 28 GHz rf field distribution of the simulated polarizer. The groove shape is expressed by

$$f(u) = \begin{cases} e^{-(a_u u)^4} & (u \leq 0.5) \\ f(1-u) & (\text{otherwise}) \end{cases}, \quad y = d \cdot f\left(\frac{x}{p}\right), \quad (1)$$

where x is the length perpendicular to the gratings on the mirror surface, y is the length normal to the mirror, p is the period of the grating, d is the width of the grating, and a_c corresponds to the duty ratio in the case that a groove shape is rectangular, respectively. This expression fulfills low ohmic loss and no sharp edges when the direction of an incident wave is normal to the grating surface.[2] In Fig. 1, the incident wave of the HE_{11} mode with E-plane linear polarization is excited at the miterbend inlet. The E-plane wave is reflected at the bottom of the grooves. The perfect matched layer (PML) is artificially set on the miterbend outlet so that the reflected wave can be absorbed in the PML to prevent further reflection.

Then, the ohmic loss is evaluated on the groove surface using the impedance boundary condition, where the surface currents cause the ohmic loss on the copper mirror with the finite electrical conductivity. Figure 2 shows the ohmic loss on the groove surface as a function of duty ratio a_c for (a) $\lambda/8$-type and (b) $\lambda/4$-type polarizers with $p = 0.5\lambda$, respectively, where λ is the wavelength. The results indicate that $a_c = 6$ gives minimal loss for both of the polarizers.

However, it is found that the rounded rectangular shape[1] is easier to be fabricated by mechanical machining than the shape expressed in Eq. (1) is, so that good surface roughness with the rounded shape is achieved. Moreover, no difference in ohmic loss between the two shape functions is found. Figure 3 shows pictures of a successfully fabricated rounded-rectangular-shape polarizer with a smooth surface.

1) Ii, T. *et al.*: Rev. Sci. Instrum. **86** (2015) 023502.

2) Plaum, B. *et al.*: J. Infrared Milli. Terahz Waves **32** (2011) 482.

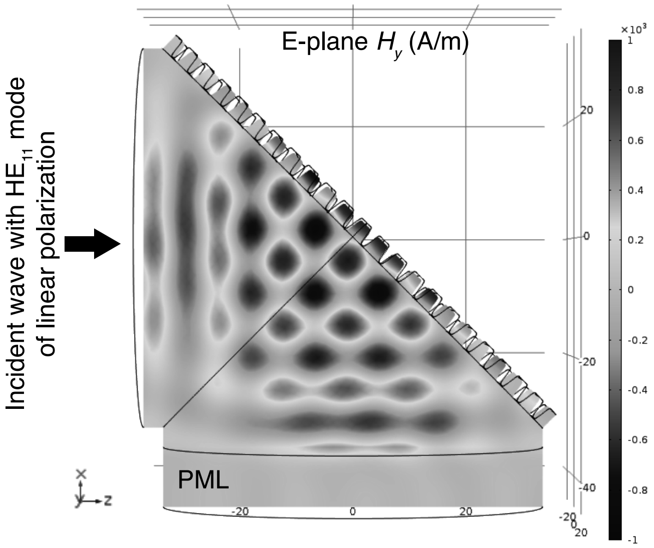

Fig. 1. Example of 28 GHz rf field distribution in a simulated miterbend polarizer. The incident wave with E-plane polarization is reflected at the bottom of the grooves and the reflected wave is absorbed in the artificial perfect matched layer (PML) to prevent further reflection.

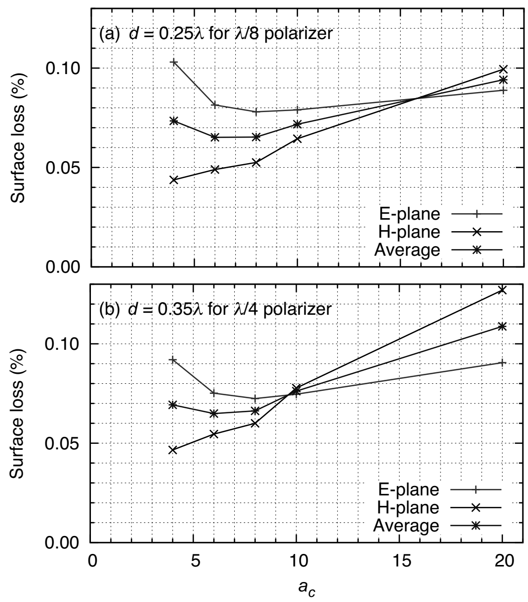

Fig. 2. Ohmic loss evaluated on the groove surface as a function of duty ratio a_c for (a) $\lambda/8$-type and (b) $\lambda/4$-type polarizers, respectively.

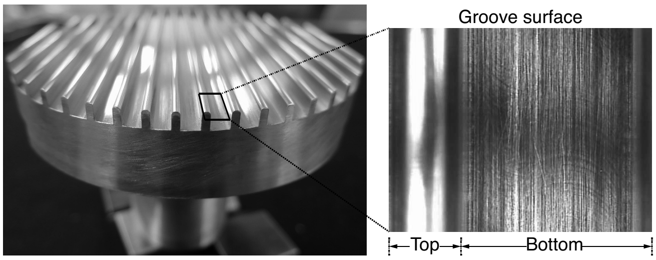

Fig. 3. Fabricated polarizer by mechanical machining.