§17. Design of Polarizers for a High-power Long-pulse Millimeter-wave Transmission Line on the LHD

Ii, T., Kubo, S., Kobayashi, S., Makino, R., Shimozuma, T., Yoshimura, Y., Igami, H., Takahashi, H., Mutoh, T.

The polarizer is one of the critical components in a high-power millimeter-wave transmission line. It requires full and highly efficient coverage of any polarization states, high-power tolerance, and low-loss feature. Polarizers with rounded shape at the edge of the periodic groove surface are designed and fabricated by the machining process for a high-power long-pulse millimeter-wave transmission line of the ECH system in the LHD.[1)]

The groove shape of $\lambda/8$- and $\lambda/4$-type polarizers for an 82.7 GHz transmission line is optimally designed in an integral method developed in the vector theories of diffraction gratings[2)] so that the efficiency to realize any polarization state can be maximized. Figure 1 shows the polarizers manufactured by machining along with the profile of the rounded rectangular shape. By calculating the reflected wave from the combination of these polarizers, whether any polarization state is realized with the combination is evaluated. Figure 2 shows the polarization state of the combination of the optimally-designed $\lambda/8$- and $\lambda/4$-type polarizers, which indicates that almost all of the polarization states are realized. Since the polarization performance is nearly identical with that of the rectangular-grooved polarizers, the polarization ellipticity β can be changed almost only by rotating $\lambda/8$-type polarizer, while the polarization angle α can be changed almost only by rotating the $\lambda/4$-type polarizer with β fixed, which results in easy setting of a polarization state.

The calculated polarization state is compared precisely with experiments in a low-power test with the newly-developed fast polarization monitoring system. The elliptically polarized wave received with a circular corrugated horn antenna is divided into two orthogonal linearly polarized waves by an orthomode transducer. Using harmonic heterodyne detection with a common local oscillator, the two IF signals are directly acquired by a fast digitizer with a FPGA. FFT into the signals enables us to calculate the polarization state almost in real time. The test results show that the measured polarization characteristics are in good agreement with the calculated ones within the margin of measurement errors.

The surface roughness of the grooves fabricated by machining is measured five times better than that by wire-electro discharge machining. The smooth surface is considered to exhibit low power loss. It is the future work to examine whether this difference affects power loss on the polarizer surface.

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

2) Maystre, D.: in *Progress in Optics* (North-Holland Physics Publishing, Amsterdam, 1984) **XXI** I.

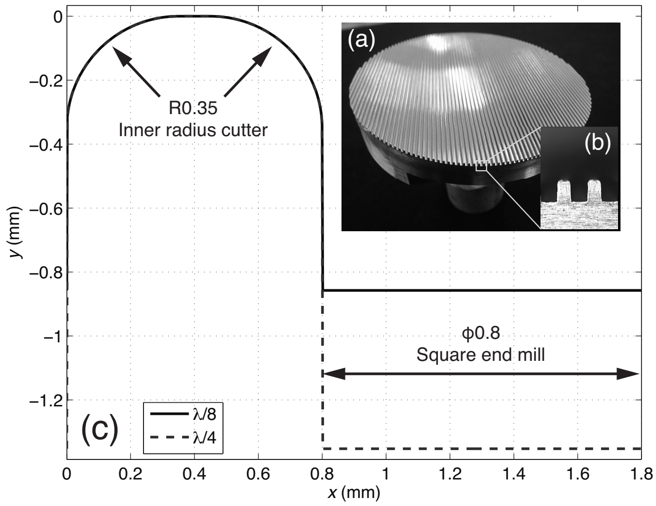

Fig. 1: (a, b) A photo of the polarizer manufactured by machining in our machine shop and (c) the groove shape optimally designed. The groove depths of the $\lambda/8$- and $\lambda/4$-type polarizers for f = 82.7 GHz are designed 0.86 mm (~ 0.24λ) and 1.35 mm (~ 0.37λ), respectively. The top edges are rounded circularly by an inner radius cutter with a radius of 0.35 mm. The milling machine with a square-edge end mill with a diameter of 0.8 mm runs back and forth to make the groove width of 1.0 mm.

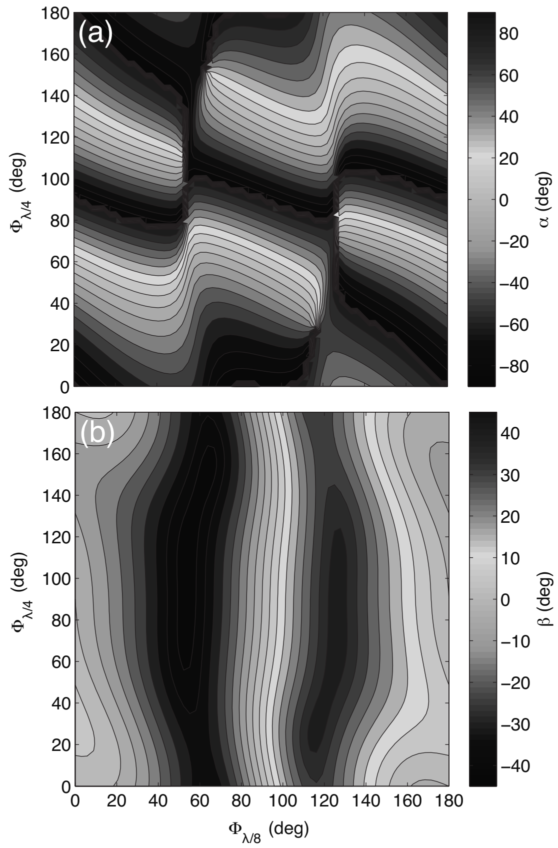

Fig. 2: Polarization state (a) α and (b) β as a function of polarizer rotation angles ($\Phi_{\lambda/8}, \Phi_{\lambda/4}$) for the combination of the optimally-designed $\lambda/8$- and $\lambda/4$-type polarizers.