

LIGA Sub-terahertz Mode Converter

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The circular waveguide mode, featuring azimuthally symmetric electric field and low wall loss, has drawn much attention in relation to a variety of applications, such as electron-cyclotron devices, gyrotrons, plasma processing systems, novel linear colliders and antennas. In the previous study [1], we present a sidewall coupling 200 GHz mode converter (Fig.1), which takes advantage of the wave nature to excite a pure mode. This converter allows the electron beam to pass through it and to interact with the wave; thus, it is especially suitable for gyrotron amplifier and oscillator applications. However, with increasing the frequency (f) of EM wave, the dimension tolerance of the component is approximately proportional to λ , and the skin depth of the EM wave is relative to λ . That means the machining quality is highly demanded. The typical surface roughness with mechanical machining is around 500 nm; but, our simulation results indicate the transmission efficiency of the mode converter degrades obviously when the surface roughness is higher than 100 nm.

In this work, X-ray micromachining (or LIGA technique) was used to fabricate the 200 GHz mode converter. All the relative LIGA processes, including X-ray mask fabrication, deep X-ray lithography, pulse electroplating, were optimized to realize a 200 GHz mode converter. AFM measurement shows that the surface roughness (Ra) is around 50 nm, much better than that by EDM machining.

The plating layer is then surface ground to the designed thickness with a tolerance of ± 0.005 mm. High-precision milling was applied to machine the circular interaction section of the mode converter. Four dowel pins are used to ensure precise alignment of the parts during device assembly. Another four through-holes close to the center are fastened with screws as shown in Fig. 2. Once the parts were machined, high-flux radicals produced from a plasma source was used to remove the epoxy-based resist.

Preliminary measurements (Fig. 3) show that the transmission behavior of the mode converter is similar with simulation result; however, the transmission efficiency has to be improved further. We believe the mechanical drilling of the beam tunnel degrades the performance of the LIGA mode converter, and it will be continuously improved. However, LIGA seems to be a promising technology for fabricating ultra-thick and high-precision devices in the Terahertz range.

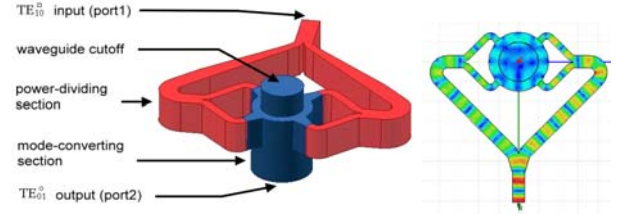


Fig. 1: (left) Schematics of the mode converter. (right) Simulation of the TE41 field in the cavity.

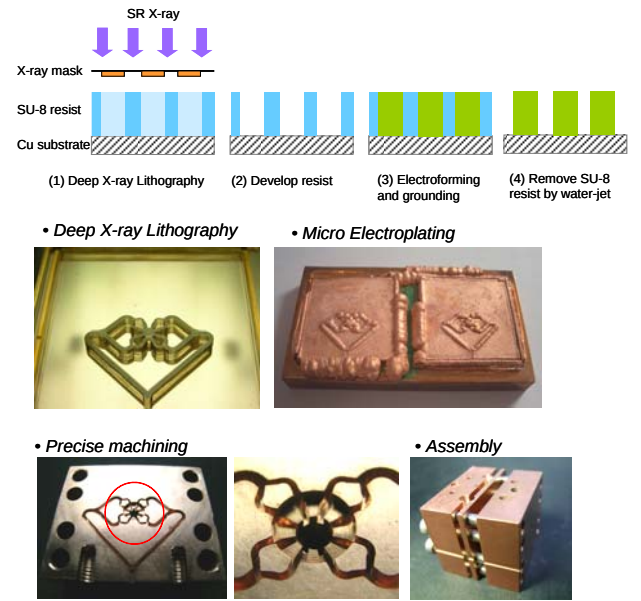


Fig. 2: X-ray micromachining process of the mode converter.

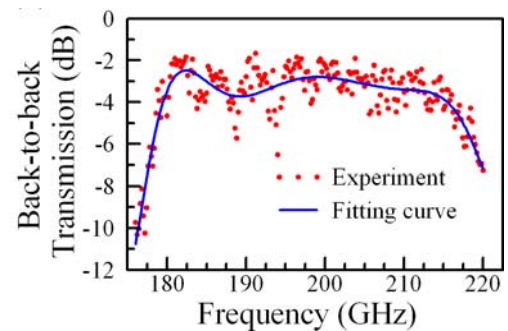


Fig. 3: Preliminary Measurement of the 200 GHz mode converter. The dots are the measured results. The solid line is the fitting curve using the least square fitting.

Reference

- [1] T. H. Chang, C. H. Li, C. N. Wu, and C. F. Yu, Appl. Phys. Lett. **93**, 111503 (2008).