Backward Wave Oscillator Development at 300 and 650 GHz

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A 300 GHz backward wave oscillator (BWO) is presently in fabrication and the design of a 650 GHz BWO is nearing completion. Both devices make use of the novel biplanar interdigital slow wave circuit and patented GENVAC technology for the fabrication of intricate chemical vapor deposition (CVD) diamond structures.

The 300 GHz BWO is intended for an application requiring a tuning range of up to 20%, and the slow wave circuit has recently been redesigned to provide an estimated increase in output power of 59% over the original prediction. The 650 GHz BWO design is optimized for operation at a fixed frequency. Taking advantage of the shorter wavelength, the 650 GHz BWO is designed with an output coupler consisting of an antenna that is as an integral part of the diamond structure, while the 300 GHz BWO utilizes a conventional probe through waveguide wall output coupler.

The predicted power output and efficiency of the 300 GHz BWO as delivered to the output waveguide varies from 28.5 mW and 4.5% at 285 GHz to 35.2 mW and 3.1% at 315 GHz. The mass of the 300 GHz BWO will be approximately 326 gm and will occupy the approximate volume of a 50 mm cube. The predicted performance of the 650 GHz BWO is 23.8 mW and 1.6% efficiency from the antenna to free space.

In the biplanar interdigital circuit, the opposing sets of fingers are placed on parallel planes forcing the electromagnetic wave to propagate in the space between them. The sheet electron beam passes through the space between the planes in a region of very high interaction impedance. The result is a compact, relatively efficient sub mm signal source.

The structure is fabricated from CVD diamond that is grown in a silicon mold fabricated using deep reactive ion etching (DRIE). The electron gun is fabricated as an integral part of the slow wave circuit to avoid the difficulty of aligning the two sections during assembly. The BWO body is assembled using techniques customarily applied to the fabrication of liquid crystal displays. A Spindt field emitter rated to deliver 1.8 mA is used as the electron source. The electron beam is controlled by two NdFeB 50 bar magnets, which provide for the 300 GHz BWO a uniform field of 0.55 T.

For the 300 GHz BWO, the slow wave circuit is placed in a metal structure, which contains the output coupler and waveguide. The entire assembly is supported mechanically within an aluminum oxide cradle that provides electrical isolation and also serves as a supporting structure for the electrodes of the two stage collector. The assembly drawing of the 300 GHz BWO is shown in Figure 1.

The 600 GHz BWO is design for operation with a 2.0 mA electron beam. The cathode current density is designed to be the same as the 300 GHz BWO, but the higher current density in the beam tunnel will require a higher axial magnetic field of 0.8 T. The supporting structure is similar to the 300 GHz BWO.

Most of the parts shown in the drawing are in house awaiting assembly. The mask design for the fabrication of the silicon molds for the diamond deposition is shown in Figure 2. One 100 mm silicon on insulator (SOI) wafer produces components for 57 BWO bodies.

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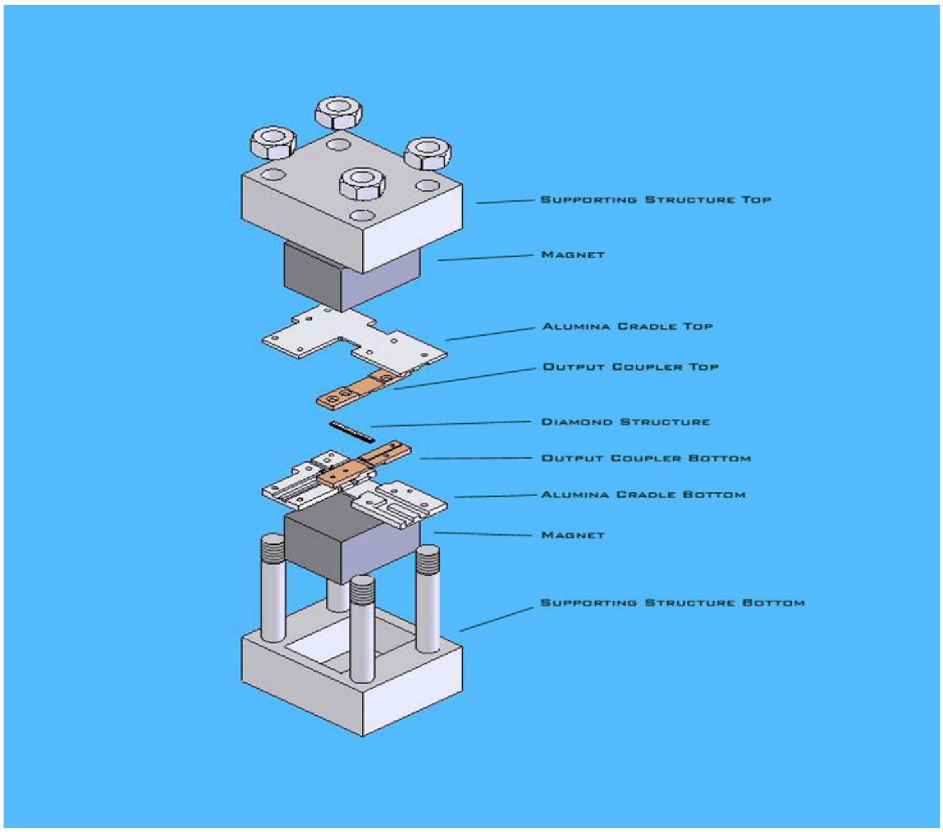

Figure 1: Exploded view of the 300 GHz BWO assembly.

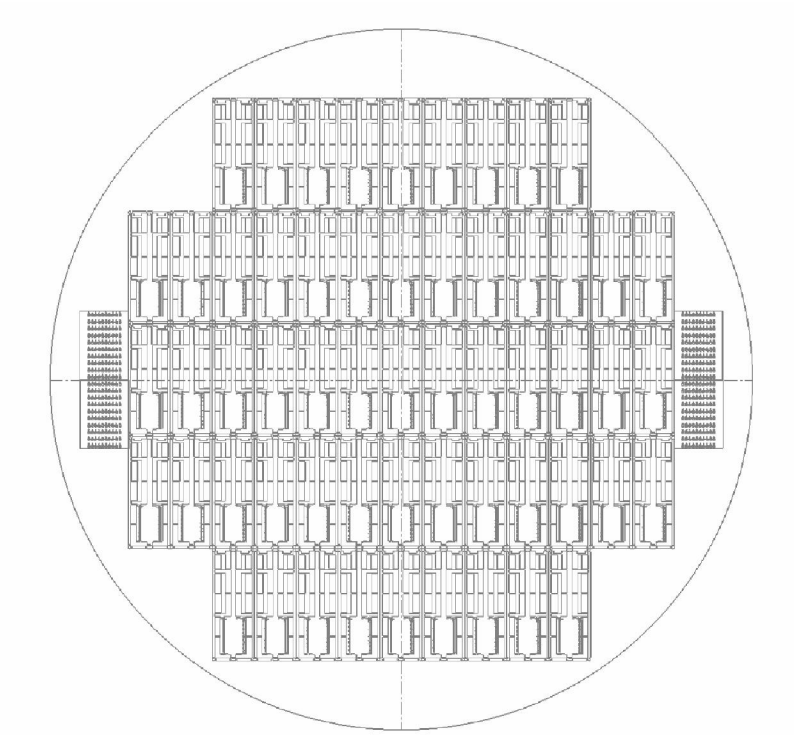

Figure 2: Mask for the DRIE of 100 mm SOI wafers to produce 57 BWO bodies.