Development of Backward Wave Oscillators for Terahertz Applications

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Calabazas Creek Research, Inc. (CCR) is developing advanced backward wave oscillators (BWOs) operating from 300 GHz to more than 1 THz. The BWOs will be used by the National Aeronautics and Space Administration as local oscillator sources in heterodyne receivers for low-background astronomy observations and remote sensing. Above 100 GHz, only BWOs have broad tunability (over 100 GHz) and high output power (~1 mW). The current program will reduce the weight, improve the efficiency, and extend the operating range of these devices.

CCR is working with Sandia National Laboratory to utilize advanced masking and etching techniques to reduce manufacturing cost and achieve unprecedented feature sizes. This will allow significant reduction in the periodicity of the BWO circuit, reducing the operating voltage and extending the operating frequency to more than 1 THz. Several hundred circuits can be made on a single wafer, significantly reducing the cost and improving reliability. The circuits will be manufactured using the LIGA process, and the results will determine what frequency range can be achieved. The current 600-700 GHz BWO requires feature sizes of approximately 20 microns, while LIGA is capable of producing feature sizes on the order of 5 microns. This indicates that frequencies approaching 2 THz may be achieveable.

The output coupling into waveguide was previously redesigned to increase the amount of usable power by a factor of 5 in the 600-700 GHz BWO. Similar designs are now in progress to extend these techniques to the higher frequency BWOs.

The current BWO utilizes an external permanent magnet to provide the 1.1 T field required for beam confinement. Recent research on W-Band sources developed techniques to confine electron beams using periodic permanent magnets within the vacuum envelope[1]. Research is underway to determine if such techniques can be applied to the BWOs. If successful, the weight of the BWO system would be reduced from approximately 20 Kg to a few hundred grams with a similar reduction in size.

Finally, the prototype BWOs will incorporate a single stage depressed collector for energy recovery from the spent electron beam. Simulations indicate that approximately 80% of the energy can be recovered, significantly increasing the device efficiency. The will reduce the electrical power requirement and eliminate water cooling.

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1. Glenn Schietrum, A. Burke, G. Caryotakis, A. Haase, L. Song, ì W-Band Klystron Research,î Pulsed Power Plasma Science 2001, 28thy IEEE Intern. Conf. Plasma Sci., June 2001, Las Vegas, NV.