Submillimeter Wave Sources and Receivers; Creating a Practical Technology Base

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To meet the requirements of new generations of scientific projects, there is a need for broadband, compact, rugged and reproducible sources and receivers at submillimeter wavelengths. For example, the Atacama Large Millimeter Wave Array (ALMA) requires electronically tunable sources covering the range 100 GHz to 1000 GHz with individual bandwidths of up to 25%. As another example, CoSSIR, an instrument developed at Goddard Space Flight Center to measure cirrus-cloud and water vapor profiles, has a need for ultra-compact rugged receivers up to 870 GHz. This talk will discuss the development of sources and receivers applicable to these and other projects. The ultimate goal of this research is to create a technology base that expands the use of the terahertz spectrum to more routine but equally important scientific and military measurements, and in the longer term to enable a wide range of commercial applications.

A series of full-waveguide band tunerless multipliers, including doublers, triplers and quintuplers, have been developed at frequencies up to 1.7 THz. These multipliers use no bias, and have a very simple construction, thus making them amenable to construction in large quantities. For example, the WR-2.8X3 broadband tripler, used for ALMA band 7 (LO range 282-366 GHz), covers the entire band 265-400 GHz with typical efficiency of about 3.5%. A quantity of 139 WR-2.8X3 triplers, as well as an additional 139 WR-3.4X3 Band 6 triplers, were built and fully tested in the course of about 4 months. The multipliers were found to be extremely consistent, in terms of both conversion efficiency and input return loss. With the Band 6 and 7 triplers completed, work is now underway on the development of multipliers for other bands, which will be discussed further at the conference.

A range of broadband room temperature receivers have been developed with RF bands from WR-8 (90-140 GHz) to WR-1.2 (600-900 GHz). These receivers use subharmonic mixers, which allow for the use of an LO at half the RF, and also provide LO noise suppression. Measurements at 600 GHz on a WR-1.7 subharmonic mixer have yielded a mixer noise temperature of 1550 K (DSB) and a conversion loss of 8 dB (DSB) using only 4 mW of LO power at 300 GHz. The development of a WR-1.2 mixer, covering the range from 600-900 GHz, will be discussed at the conference. Because of the need for compact receivers, particular emphasis will be given to the size and DC power requirements of these receivers.

The terahertz circuit designs discussed here represent a novel and innovative solution for terahertz source and receiver applications. Their inherent simplicity is a primary benefit and their proven THz performance is extremely encouraging. Additionally, our GaAs-on-dielectric fabrication process is well established and has been shown to be quite robust. This technology is ideal for a variety of science applications such as airborne atmospheric sensing and long duration flights to study the atmospheres of other planets, as well as a range of military and commercial applications, including imaging systems and potentially bioagent and chemical scanners.