Next Generation of Room-Temperature Broadband Frequency Multiplied LO Sources with 10 times Higher Output Power in the 100 GHz – 1.9 THz Range

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Abstract — Building upon the tremendous success of the Heterodyne Instrument for the Far Infrared (HIFI) on board the Herschel Space Observatory, high-resolution submillimeter-wave receivers able to map galaxies at unprecedented speeds have been proposed for a number of future NASA missions to address key unanswered questions about the stellar life cycle. Almost 10 years after Herschel was launched, Schottky diode frequency multiplied local oscillator sources are still the preferred local oscillator technology for these receivers. Unlike other competing technologies, Schottky based LO sources are compact, broadband, frequency stable, temperature stable, and can operate at room temperature.

To meet the requirements of the next terahertz heterodyne array instruments, it was necessary to push the limits of the current Schottky technology even further to achieve unprecedented output power levels while preserving or even improving the form factor of the LO sources and reducing the overall dc power consumption to make them suitable for suborbital or space missions.

Here we are presenting the newest generation of compact THz LO sources recently demonstrated at JPL, which exhibit output power levels more than 10 times higher than the previous state-of-the-art. These are based on a novel JPL-patented circuit topology called “on-chip power-combining”. This concept, together with a precise optimization of the devices for high-power operation, yields an improvement in power-handling capabilities by one order of magnitude without using multiple-chips power-combined structures or diamond substrates. These results represent a major breakthrough in power generation at terahertz frequencies, and contribute enormously to closing the so-called “terahertz gap”. Prototypes at 180 GHz, 240 GHz, 340 GHz, 530 GHz, 1 THz and 1.6 THz have been designed, fabricated, assembled and tested at JPL all with world record performances. For example, output power levels of 550 mW (25% efficiency) at 180 GHz, 130 mW (15% efficiency) at 230 GHz, 30 mW (7% efficiency), 2 mW (5% efficiency) and 0.8 mW (3% efficiency) have been measured at 300K. This also translates to world record input power handling capabilities. The conversion efficiency for all these stages is also state-of-the-art and pretty close to the theoretical limits predicted using physics-based numerical simulators. Further improvements could still be achieved by cooling the sources down to 120K. With this new generation of LO sources available, large arrays of high-resolution terahertz receivers can now be driven with a single broad-band compact source.