Progress towards a Room-Temperature 4.7 THz Multiplied Local Oscillator Source to Enable Neutral Oxygen Observation

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Oxygen is the third most abundant element in the Universe, and knowledge of the chemistry of oxygen in interstellar clouds and protostellar regions is essential for understanding the formation of stars and the incorporation of key molecules into forming planetary systems. The OI line at 63 um (4.7 THz) together with CII (158 um) are the major coolants of photo-dissociation regions in giant molecular clouds. However, the OI line at 4.7 THz has never been observed with resolutions better than 7 km/s. Leveraging off of the success of the HIFI instrument on-board the Herschel Space Observatory, our objective is to develop the first all-solid-state Schottky diode based broadband frequency multiplied local oscillator source at 4.7 THz able to provide the minimum required output power (>1 µW) to drive a Hot Electron Bolometer mixer, and thereby enabling high-resolution ($\lambda/\Delta\lambda > 10^6$, $\Delta v < 0.3$ km/s) heterodyne spectroscopy of the fine atomic oxygen line at 63 µm.It will be compact, broadband, frequency-agile, tunable, temperature, frequency stable and able to operate at room-temperature.

Our strategy will consist of a X2X3X3X3 multiplication scheme (see Fig. 1) featuringa number of new technologies and novel multiplier concepts to provide frequency multipliers with the necessary enhancements to improve the state-of-the-art by at least a factor of 5 in terms of power and almost a factor of 2 in terms of maximum operation. We will use for the first time GaN based multipliers in the lower stage to increase power handling capabilities, novel on-chip power combining techniques to increase the input/output power of current GaAs multipliers by a factor of up to four, and silicon micromachining techniques to produce waveguide blocks with lithographic precision (< 1 um) in order to make it possible to fabricate waveguide blocks operating up to 4.7 THz. The silicon micromachining technique developed at our group also allows 3D integration by vertical stacking the device wafers (see Fig. 1 –right), which leads to ultra-compact LO sources. The progress on the design and development of the different novel components of this 4.7 THz LO source will be discussed.

At the conclusion of this project we will also provide NASA with multi-pixel capabilities for the entire terahertz region (up to 5 THz), highly demanded for future astrophysics missions such as SOFIA, STO-2, GUSSTO, etc.

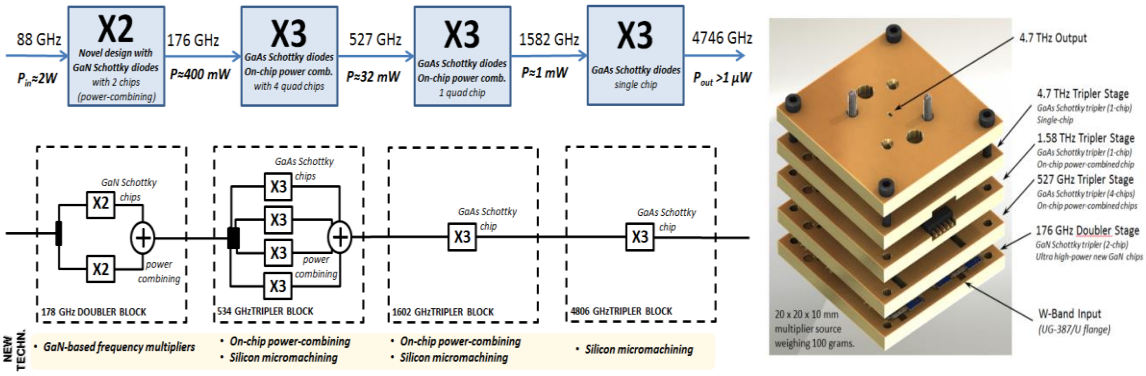

Fig.1. General scheme of the 4.7 THz frequency multiplied LO source.

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