High-Efficiency Planar Schottky Diode Based Submillimeter-Wave Frequency Multipliers Optimized for High-Power Operation

Jose V. Siles, Erich Schlecht, Robert Lin, Choonsup Lee, and Imran Mehdi

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 91101

***Abstract*—We report on a new series of millimeter and submillimeter-wave frequency multipliers specifically optimized for very high-power operation in order to meet the requirements of next generation terahertz instruments for Astrophysics, Planetary science, Earth science and radar imaging applications. New frequency multiplier chips have been designed and fabricated in the 100 GHz to 1 THz range focusing on higher power operation. Initial tests have shown efficiencies of around 30% for a single-chip 105-120 GHz tripler, and 25% for a single-chip 170-200 GHz doubler, when pumped with 500 mW. These results correspond to a factor of 2-3 improvement with regards to previous designs at these frequencies. Similar improvements are expected for the new designs at higher frequencies.**

I. SUMMARY

THe next generation of terahertz instruments currently under development require much more powerful local oscillator sources in order to satisfy their operational requirements [1, 2]: high transmitted power in for radar-imaging applications, multi-pixel capabilities for heterodyne cameras in Astrophysics, high room-temperature sources to drive Schottky diode based receivers for planetary science, etc. Using traditional power-combining techniques has been a natural and straight-forward solution so far since available chips could be used [3]. However, as the required number of pixels (or frequency of operation) increases, this is not a viable solution since the required number of chips is large and the complexity of the system architecture increases exponentially: multiple dc bias lines, additional waveguide losses, circuit imbalances due to electrical differences between devices, etc.

Schottky diode based frequency multiplied terahertz local oscillator sources in use nowadays are mainly based on the original designs used for the HIFI instrument on-board the Herschel Space Observatory, which are relatively low power designs. Due to the non-linear properties of Schottky diodes, using current chips with increased input power levels is inefficient in terms of efficiency and thermal management. However, by a proper re-optimization of the diode structure, chip architecture, an improvement of a factor of more than 2 in power handling capabilities of single-chip frequency multipliers can be achieved, with no penalty in efficiency with regards to state-of-the art designs.

II. RESULTS

To demonstrate this, we have designed and fabricated a new series of single-chip frequency multipliers from 100 GHz to 1 THz specifically optimized for high-power operation. Initial tests have shown efficiencies of around 30% for a single-chip 105-120 GHz tripler, and 25% for a single-chip 170-200 GHz doubler, when pumped with 500 mW. These results correspond to a factor of 2-3 improvement with regards to previous designs at these frequencies. A comparison between the new 170-200 GHz doubler chip and the original design used for the HIFI instrument on-board Herschel Space Observatory is shown in Fig. 1. Split waveguide housing blocks for the higher frequency designs are currently being fabricated and will be texted soon.

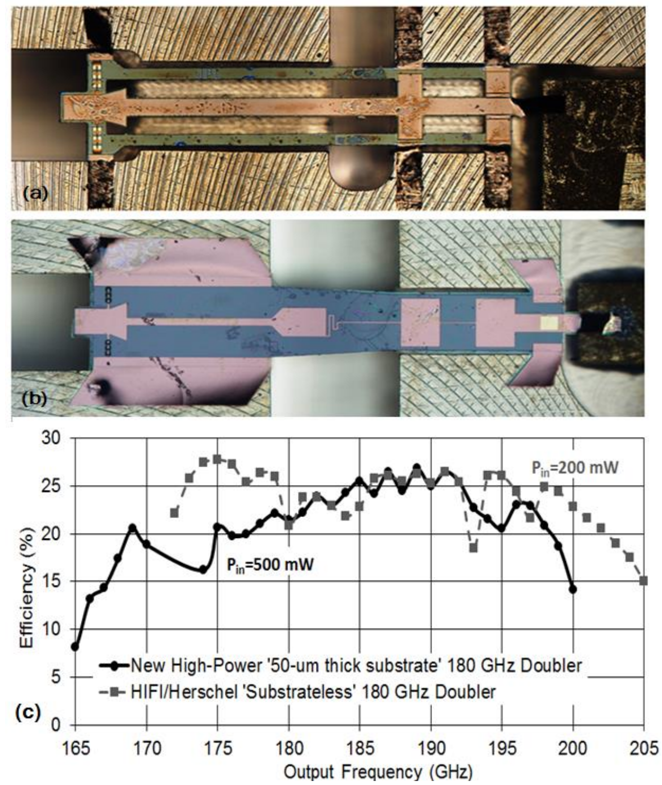

Fig. 1. (a) HIFI/Herschel medium-power 170-200 GHz doubler chip (designed for 100 mW nominal input power); (b) new high-power 170-200 GHz doubler chip (designed for 250 mW nominal input power); (c) Measured performance for both designs: input power is 200 mW for the HIFI design, and 500 mW for the new design.

III. ACKNOWLEDGEMENT

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