Silicon Micromachined Integrated 4-Pixel Heterodyne Receiver at 1.9 THz

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Abstract—Deep reactive ion etching (DRIE) based silicon micromachining technology is proving to be one of the most suitable option for the fabrication of next generation of terahertz multi-pixel heterodyne instruments. Silicon micromachining provides high precision fabrication capabilities and high level of integration within the receiver. Moreover, it enables the fabrication of hundreds or thousands of pixels from a single wafer, which reduces cost, saves time, and allows to develop multi-pixel arrays in a fast parallel path instead of serial nature of current generation of multi-pixel instrument architecture.

We are developing a highly compact 4-pixel heterodyne receiver at 1.9 THz with integrated orthomode transducer (OMT) for dual-polarization capability and a balanced receiver architecture fabricated with micromachined silicon waveguide packaging. Fig. 1 shows the block diagram of the proposed receiver architecture and the waveguide implementation of the receiver. The receiver has a dual-polarized antenna which couples the incoming radiation to an OMT where the signal is separated into two linear polarizations. Each signal goes into a 90-degree waveguide hybrid coupler that divides the RF signal equally between the two output ports with 90-degrees phase difference. The LO signal is injected through the isolated port of the hybrid and the combined RF and LO signals feed two sets of HEB mixers in a balanced configuration. The IF outputs are then combined in a 180- degree hybrid obtaining the corresponding polarization signal, as shown in Fig. 1.

One of the challenges of the development of multi-pixel heterodyne receivers is the antenna array. For single-pixel instruments, horns are widely used because of their good performance and bandwidth. However, for multi-pixel instruments, these antennas struggle in terms of fabrication –higher frequency requires higher fabrication tolerances – and integration with the rest of the detector because of their volume, mass, and the difficult integration of silicon and metal at cryogenic temperatures. Thus, having an antenna that can be fabricated in silicon micromachining techniques is essential for these receivers. We developed a silicon microlens based array antenna that can be integrated with the silicon micromachined receiver. In this design, the gold plated micromachined silicon wafers are vertically stacked to reduce loss and provide a highly integrated receiver system. The key advantage of having this vertical integration architecture is that we can easily transition to a two-dimensionally arrayed multi-pixel system.

In this paper, we will describe the design of the 1.9 THz silicon micromachined receiver system, the microlens antenna design, fabrication techniques with DRIE based silicon micromachining, assembly of the components, and preliminary test results.

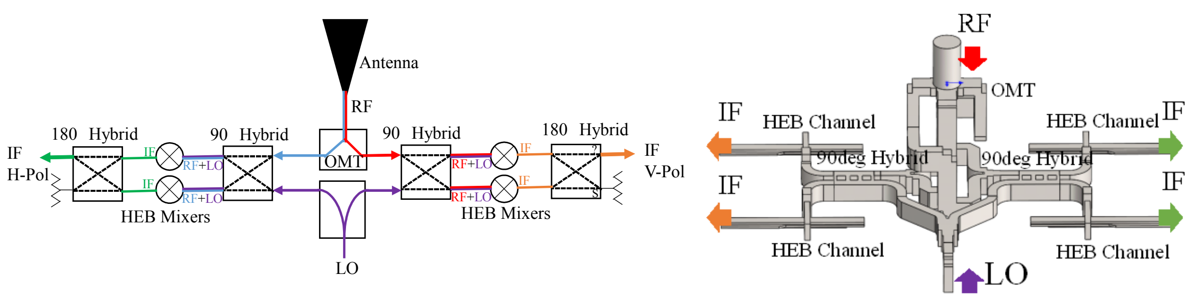

Figure 1: (a) Block diagram and (b) actual waveguide design of the dual-polarized, balanced receiver front-end at 1.9 THz fabricated with silicon micro-machining technology.

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