Large RF Bandwidth Waveguide to Thinfilm Microstrip Transitions on Suspended Membrane for use in Silicon Micromachined Mixer blocks at THz Frequencies

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With the advent of broad bandwidth low noise Hot Electron Bolometer (HEB) mixers at Terahertz frequencies, there is a need for a large RF bandwidth (scalable) waveguide to thin-film transition. At present nearly all HEB receivers operating above 800 GHz are implemented in quasi-optical (twin-slot, log-periodic, dipole) structures. This despite the fact that waveguide technology offers the prospect of higher throughput, better telescope coupling, and large format imaging arrays with well aligned beams on the sky.

There are several reasons for the use of open structure mixers in the THz regime. First, though there are many excellent fixed tuned waveguide probe designs in circulation, they nearly all are implemented in reduced half-height waveguide structures. Not only are these reduced height waveguides difficult and expensive to fabricate above 700 GHz, they also have significantly increased Ohmic loss when compared to a full height waveguide block at the same frequency. Secondly, even if a reduced height waveguide block at THz frequencies could be made, the actual device (usually mounted on a quartz substrate) becomes too small to handle or space qualify. Finally, up to now it has been difficult to realize a fixed tuned low loss full-height waveguide transition with a fractional bandwidth comparable to that of well designed quasi-optical (twin-slot) devices.

Fortunately, we are able to overcome these obstacles with the use of thin-film microstrip radial probe transitions on suspended membrane in full waveguide height silicon micro-machined mixers blocks. To maximize the RF bandwidth and coupling efficiency we utilize photonic crystal structures to suppress leakage directly above and below the membrane. It is seen that this work is applicable to both single element and multi-element array receivers. Membranes thickness is adapted to facilitate both phonon-cooled and diffusion cooled HEB's. Diffusion cooled HEB's on 1um Silicon-Nitride have been fabricated at UVa, Phonon cooled HEB devices on NbTiN films are expected in the very near future. Detailed HFSS simulation results of the proposed design are presented.