Our group investigates materials, processing technologies and devices for THz technologies. The driving force of this research has been the need for ultra-low-noise heterodyne receivers at the millimeter and submillimeter wavelengths. Of particular interest is the investigation and development, with the National Radio Astronomy Observatory, of complex integrated superconducting SIS mixers for the new International Atacama Large Millimeter/submillimeter Array. Additional ultra low noise detectors include superconducting nano-sized hot electron bolometers at THz frequencies for both machined waveguide and quasi-optic receiver architectures. Our group is also a leader in the development of heterodyne array detectors including the 64 pixel Supercam Array in collaboration with University of Arizona and Arizona State University.
**Terahertz Mixer/Receivers**

In recent years, engineers and scientists have intensified their efforts to build detectors, mixers and receivers operating in the millimeter, submillimeter-wave and THz region. Electromagnetic radiation in the THz range has found many applications in chemical spectroscopy, bio-sensing, medical imaging, security screening, and defense. Additionally, THz waves are critical for radio astronomy and astrophysics because they contain spectral information concerning the interstellar medium, cosmic background radiation, and formation of new galaxies. However, the THz band has not been fully explored, large due to the difficulty of building robust, high performance detectors and mixers that can operate with the necessary sensitivities at these frequencies. Our group, for over thirty years, has collaborated with astronomers around the world to develop ultra-low noise and wideband heterodyne detectors using Superconducting Insulating Superconducting (SIS) junction, nano Hot Electron Bolometer and Schottky Diode devices.

**SIS Mixers at High Frequencies**

We are focusing on the development of technologies for improved superconductor insulator superconductor (SIS) mixers at high frequencies. Important to this next generation of detectors is the replacement of the Nb counter electrode with a higher energy gap NbTiN superconductor for higher frequency operation. Additionally, we are optimizing our ICP plasma grown AlN tunnel barriers from Al overlayers for higher current densities. We are also investigating the spectral distribution of the ICP nitrogen growth plasma to optimize the growth process for low leakage junctions. Finally, we are working on the realization of 4.2K whole wafer dc I-V probing of mixer chips and the investigation of all NbTiN SIS material structures.

**HEB Fabrication Technology**

We are investigating the development of an alternative Ebeam lithography based HEB device fabrication process to complement our Ti-line nano fabrication process. Once in hand, the project proceeds to the development of a 1.6THz single pixel HEB receiver for NGIC.

**THz Wafer Probes**

With DARPA supported research, we have developed micromachined Silicon-On-Insulator (SOI) wafer probes in the first demonstration of on-wafer probes operating above 500 GHz for the measurement of S parameters. This technology uses our ultra-thin Si and Au beam lead architecture to realize robust probe chips that are clamped in a waveguide probe block. We have also recently developed the first terahertz frequency (>0.5 THz) on-wafer probe station in the world. The instrument development project realized a full two-port terahertz frequency vector network analyzer (VNA) system with frequency extension modules (VNA extenders) mounted to a commercial probing platform. The system utilizes the wafer probes developed at UVA that we have now successfully demonstrated up to 900 GHz.

**RECENT RESEARCH DEVELOPMENTS**

- In collaboration with NRAO, we have developed Nb/Al-AlN/Nb SIS mixers that have exceeded the ALMA Band8 receiver noise specifications.
- With DARPA support, we have invented a new Wafer Probe Technology and demonstrated the first Wafer Probe operating above 500GHz (and more recently up to 900GHz).
- Fabricated SOI beamlead SIS chips in an ongoing NSF project for a pathfinder study for kilo-pixel heterodyne array receivers with Arizona State University, University of Arizona and Cal-Tech.

**RECENT GRANTS**

- NSF – Multiband, Ultrasensitive Terahertz Imaging Receivers Based on Quasi-Optical Hot Electron Mixers
- NRAO – ALMA SIS THz Detectors
- DARPA – Metrology & Wafer Probing for S-Parameter Characterization of THz Devices and Circuits
- NSF – A Pathfinder Instrument for Kilopixel Heterodyne Receivers