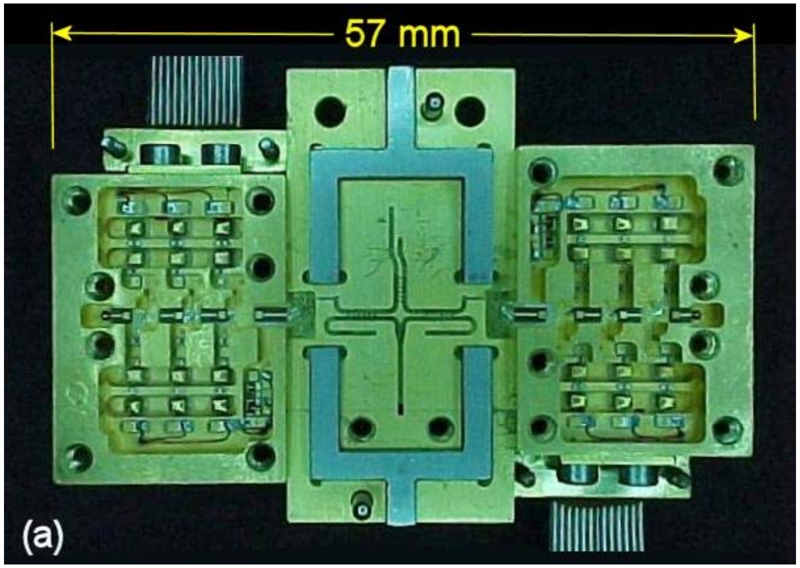
Lichtenberger Research Group



My group's research involves the investigation of materials, microfabrication technologies and designs for heterogeneous integration of new *terahertz* devices, circuits, systems and THz metrology. The impetus behind much of this research is the growing scientific interest in terahertz technologies as well as the specific interest in and need for integrated ultra-low-noise heterodyne and direct detection receivers at terahertz wavelengths. This effort began at UVA in the early 1970s with the development of semiconductor detectors for radio astronomy. Since then, UVA devices have been used in over 50 university, national, and international laboratories & astronomical telescopes including, most recently, the international, $1B, 66 dish Atacama Large Millimeter/submillimeter Array (*ALMA*) where my group's superconducting detectors drive two of the first four receiver bands. However, the focus of our THz program has also grown dramatically in the last decade with widening new thrust areas in advanced THz design, simulation and analysis methods, new receiver source and power combining arrays, advanced superconducting receiver circuits, THz support structures (including micromachined waveguide components, antennas, and RF MEMs switches and tuners), and most recently extending direct device and circuit characterization with wafer probers to THz frequencies. These efforts involve numerous cross collaborations within and outside of UVA.

Arthur Lichtenberger

Research Professor
Director of the University of Virginia
Microfabrication Laboratories
Arthurw@virginia.edu
www.ece.virginia.edu/faculty/lichtenberger.html

Dept. of Electrical & Computer Engineering
University of Virginia
Charlottesville, VA
434.924.6085

"Developing new devices and systems through heterogeneous integration for the emerging field of terahertz spectroscopy, imaging and metrology."

University of Virginia Engineering

Terahertz Mixer/Receivers

In recent years, engineers and scientist 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 and Schottky Diode devices.

SIS Mixers at High Frequencies

We are focusing on the development of technologies for improved superconductor insulator superconductor (SIS) mixers and other ancillary superconducting circuits 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 have optimized our ICP plasma grown AlN tunnel barriers from Al overlayers for higher current densities by investigating the spectral distribution of the ICP nitrogen growth plasma for low leakage junctions. Longer-term material studies have also begun on the development of large energy gap, all NbTiN electrode trilayer material for superconducting mixers well beyond 1THz. These superconductor circuits are heterogeneously integrated with ultra thin Si membrane using our SOI architecture. Finally, we are working on the realization of 5K whole wafer cryogenic probe station for the probing of superconducting devices including mixer chips.

SOI-Semiconductor Heterogeneous Integration

We are investigating the integration of semiconductor (e.g., GaAs) materials and circuits onto ultra thin Si membranes with beamleads. The semiconductor "footprint" is minimized by thinning and dry etching to realize high frequency circuit compatibility, while our UVA developed thin Si, SOI based architecture is optimal for waveguide applications.

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 1THz 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 split-block. We have also recently developed the first terahertz on-wafer probe station in the world with full two-port terahertz frequency vector network analyzer (VNA) systems mounted to a commercial probing platform. In collaboration with LakeShore Cryotonics and Dominion MicroProbes, we have also developed cryogenic probes at the WR10 and WR5 bands.

RECENT RESEARCH DEVELOPMENTS

- In collaboration with NRAO, we have investigated and optimized the ICP plasma growth chemistry for high current density AlN tunnel barriers for THz SIS mixers.
- With DARPA and Industrial support, we have invented a new Wafer Probe Technology and demonstrated the first probe operating beyond 1 Terahertz and cryogenically to 220 GHz.
- Realized SOI beamlead SIS chips in an ongoing NSF pathfinder study for kilo-pixel heterodyne array receivers with Arizona State University, University of Arizona and Cal-Tech.

RECENT GRANTS

- NRAO – UVA-NRAO Development Proposal for Superconducting Circuits (2015)
- ALMA – Advanced Materials and on Wafer Chip Evaluation for Second Generation ALMA Superconducting Mixers (2016)
- DARPA – Development of Josephson Magnetic Random Access Memory for IARPA Cryogenic Computing Complexity (2015)
- ARMY/DMPI – Differential High Frequency Wafer Probes at WR3 and WR5 (2015)

SEAS Research Information
Pamela M. Norris,
Executive Associate Dean for Research
University of Virginia
Box 400232
Charlottesville, VA 22903
pamela@virginia.edu
434.243.7683

UNIVERSITY of VIRGINIA ENGINEERING