



RESEARCH ROADMAP

Millimeter-wave frequency bands have been used in many applications for both civilian and scientific purposes. Unlike X-rays, millimeter-wave radiation sources are low energy non-ionizing sources that are relatively safe to humans. As a result, millimeter-wave imaging has become one of the most pursued technologies for bio-molecular imaging and sensing. In our future plan, antimonide-based III-V heterostructures will be developed for high-speed low-power devices, including HFETs, HBTs, and photodiodes. In addition, ferroelectric and ferrite thin films will be developed to implement novel multifunctional high-frequency passive components. Based on the aforementioned devices and components, we plan to realize a high-resolution low-power millimeter-wave optical phased-array system for biomedical image applications.

The system consists of an optoelectronic wideband signal generator (optoelectronic source, optoelectronic phase shifters, photodiodes, pulse shapers, and power amplifiers), a low-noise receiver (low-noise amplifiers, phase shifters, and detector/auto-correlator), and front-end passive circuits (circulators, filters, and antennas). The system irradiates bio-substances (e.g., proteins, genetic materials, pathogens, and lesions) with wideband submillimeter-wave signals and collects the reflected/transmitted signals to obtain absorption characteristics or directly from images of the desired targets. Considering the requirements of future medical instruments, the system should satisfy high-frequency, wideband, low-noise, and low-power criteria. To realize such a system, we will need to develop low-power antimonide-based transistors, reconfigurable ferroic-based phased arrays, and an ultra-wideband optoelectronic millimeter-wave signal generator. The proposed research topics, encompassing materials development, device fabrication, circuit design, and system integration, are summarized in the following roadmap.

Applications	High-Resolution Imaging and DNA/Protein Spectroscopy	
Circuits and Systems	Submillimeter-Wave Wideband Signal Sources	Low-Power High-Speed Phased Arrays
Devices and Components	HFETs, HBTs, and Photodiodes	Tunable, Non-Reciprocal, and Nonlinear Passives
Materials	Antimonide-Based III-V Semiconductor	Ferroelectric and Ferro/Ferri-Magnetic Oxides