Plasmonics-Enhanced Terahertz Spectroscopy

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Although unique potentials of terahertz waves for chemical identification, material characterization, and biological sensing have been recognized for quite a while, the relatively poor performance of current terahertz spectroscopy systems continue to impede their deployment in practical applications. In this talk, we will describe some of our recent results on developing new terahertz spectroscopy systems based on plasmonic terahertz radiation sources and detectors which offer more than three orders of magnitude higher signal-to-noise ratio levels compared to existing terahertz spectroscopy systems.

In specific, we will introduce new designs of high-performance photoconductive terahertz sources and detectors that utilize plasmonic electrodes to offer significantly higher terahertz radiation powers and detection sensitivities compared to the state of the art. We have recently demonstrated that the use of plasmonic contact electrodes in a photoconductive terahertz source and detector manipulates the spatial distribution of photocarriers and enhances the number of photocarriers in nanoscale distances from contact electrodes significantly, enabling efficient collection of the majority of carriers in a sub-picosecond time scale. It also allows increasing photoconductor active area without a considerable impact on device parasitics, boosting the maximum terahertz radiation power and detection sensitivity by preventing the carrier screening effect and thermal breakdown at high optical pump powers. We have experimentally demonstrated two orders of magnitude higher terahertz powers and more than one order of magnitude higher terahertz detection sensitivities from our first generation plasmonic photoconductive sources and detectors in comparison with similar photoconductive terahertz sources and detectors with non-plasmonic contact electrodes. As a result, use of plasmonic photoconductive terahertz sources and detectors in a terahertz spectroscopy setup offers more than three orders of magnitude higher signal-to-noise ratio levels compared to existing terahertz spectroscopy systems. Moreover, the presented terahertz spectroscopy setup based on plasmonic photoconductive terahertz sources and detectors is optimized for operation at telecommunication pump wavelengths, where very high power, narrow linewidth, wavelength tunable, compact and cost-effective optical sources are commercially available. Therefore, our results pave the way to compact and high-performance terahertz spectroscopy setups that could offer numerous opportunities for e.g., medical diagnostics, biological sensing, atmospheric sensing, pharmaceutical quality control, and security screening.