UCLA Henry Samueli School of Engineering
Electrical & Computer Engineering Dept.
Ph.D. Defense

Telecommunication-Compatible, Plasmonics-Enabled Terahertz Sources and Detectors without Short-Carrier-Lifetime Photoconductors

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Engineering IV, Room 67-124, Faraday Room

Zoom: https://ucla.zoom.us/j/8735125890

Abstract: Photoconductive terahertz devices require ultrafast (< 1 ps) carrier dynamics to generate and detect terahertz radiation. Conventionally, they have been heavily reliant on the use of defect-introduced short-carrier-lifetime photoconductors. While quite a few excellent results have been achieved by using short-carrier-lifetime photoconductors, the high concentration of defects intentionally incorporated in the active photo-absorbing material leads to lower carrier mobility and substantial degradation of photoconductive gain due to photocarrier scattering, trapping and recombination. Additionally, realization of many short-carrier-lifetime photoconductors is only possible at limited facilities due to the need for non-standard processes, as well as rare elements as defect-introducing dopants. Therefore, alternative approaches to realize terahertz sources and detectors have attracted increasing attention. During my doctoral studies, I have established two different approaches to develop photoconductive terahertz sources and detectors without using short-carrier-lifetime photoconductors. These approaches are based on carrier transit time reduction and photoconductor band engineering to introduce ultrafast carrier dynamics. With the strong optical field enhancement offered by plasmonic nanostructures, photocarrier generation in plasmonic photoconductors can be highly confined near the terahertz radiating elements, leading to significantly reduced transport distances for the photocarriers that facilitates broadband terahertz operation. As a result, by utilizing the plasmonics-enabled carrier transit time reduction, high-efficiency terahertz sources and detectors are realized for both pulsed and continuous-wave operation. This scheme provides a generic and reliable approach for designing photoconductive terahertz devices using various semiconductors and optical wavelengths. Moreover, by engineering the photoconductor band structure, highly reliable bias-free terahertz sources are realized with multiple orders of magnitude improvement in optical-to-terahertz conversion efficiency compared to other passive terahertz generation techniques. In particular, a record-high-power pulsed terahertz source with a radiation power of 860 μW is demonstrated using a novel graded-composition InGaAs structure. Furthermore, to minimize terahertz propagation loss in the substrate, bias-free sources are successfully implemented on a silicon substrate, which not only leads to an increased radiation bandwidth, but also enables integrability with silicon photonic platforms, largely extending the scope and potential uses of terahertz sources to a diversity of practical applications.

Biography: Ping Keng Lu received his B.S. (2012) and M.S. (2014) degrees in Electronics Engineering from National Chiao Tung University in Taiwan, and pursued his PhD degree in the Terahertz Electronics Laboratory in Electrical Computer and Engineering department at UCLA under the supervision of Prof. Mona Jarrahi. His research focuses on developing plasmonics-enhanced terahertz sources and detectors that utilize novel semiconductor structures to overcome the limitations of conventional short-carrier-lifetime photoconductors. He is the author/co-author of 5 peer-reviewed journal papers as well as 13 conference abstracts and proceedings.

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