DESIGN, FABRICATION AND PACKAGING OF DUAL-MODE RADIO FREQUENCY (RF)/FREE SPACE OPTICAL (FSO) WIRELESS COMMUNICATION MODULES

by

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ABSTRACT

The two primary wireless communication technologies, Radio Frequency (RF) and Free Space Optical (FSO), both possess unique properties and are complementary to each other. A RF/FSO dual-mode wireless communication system will provide reduced power consumption, more reliable data links, and increased data capacity and security. This thesis describes the design, fabrication, integration, packaging and testing of various RF/FSO modules using different RF front-end components and bare-die optical components, and proves the feasibility of integration of RF and FSO electronics on shared substrate with minimized cross-channel talk. This research, by creating a miniaturized low power communication node, will greatly advance the deployment of wireless communication in sensor networks, smart building, and many other emerging applications.

The packaging of a split dual-director quasi-Yagi antenna with a bare die laser diode/P-i-N(PiN) photodiode was studied first. The antenna director was modified in such a way that it can be used not only as an antenna structural component but also the bonding pads for the laser diode/PiN. Both RF channel and FSO channel were characterized simultaneously. A RF/FSO dual-channel link with the FSO operating at 2.5 Gbps was successfully demonstrated.

To improve the antenna radiation efficiency and reduce the inter-channel coupling, patch antennas on various substrates and frequency were studied. The antenna dimension was optimized for the optical device assembly while maintaining the desired return loss and radiation pattern. Both simulation and measurement results indicated that the RF-to-opto cross talk in patch antenna based RF/FSO transceiver was minimized.

In addition, the packaging of LED with patch antenna was studied for the RF and visible light dual-mode communication. A 20 Mbps visible light FSO communication link was demonstrated with a 660 nm LED and a low-K patch antenna. Metal-Semiconductor-Metal(MSM) photodetectors and testing substrate were explored for 3D integration on silicon. The parasitic capacitance of the MSM and

bonding structures were extracted by a full wave EM simulation (HFSS). Low temperature bonding of Au/In was developed.