Gas sensors that are low-power, lightweight, and rugged, while also remaining low-cost, have considerable appeal to areas from automotive to space flight. There are increasing demands for higher efficient vehicles with lower emissions in order meet regulations that are meant to mitigate or lessen the effects of climate change. An affordable, fast response sensor that can measure transient carbon monoxide (CO) and carbon dioxide (CO2) has broad application which can lead to more efficient, fuel flexible engines and regulations of harmful emissions. With compact, economical, low-power sensors that are able to continually monitor gases that are characteristic of burning materials, a distributed sensor array could be implemented on space vehicles that would allow early detection of fires, gas leaks, or other critical events. With careful selection of targeted gases, it may be possible to identify the material that is burning or smoldering, better informing the crew so that they may respond and prioritize high emergency events. Further applications may include fuel/ hazardous gas leak detection on space vehicles and atmospheric constituent sensor for portable life support systems (PLSS) used by astronauts in extra vehicular activity (EVA). Non-dispersive infrared (NDIR) sensors are attractive due to their simplicity and low-cost; and by utilizing light-emitting diodes (LEDs) in this approach, power efficient, lightweight, and stable gas sensors can be developed to meet these needs.

This thesis discusses a sensor that was developed for simultaneous, time resolved measurements of CO and carbon dioxide CO2. This sensor utilizes low-cost and compact LEDs that emit in the 3μm-5μm wavelength range. Light emission of LEDs is spectrally broader and more spatially divergent (incoherent source) compared to that of lasers, which presented many design challenges. Optical design studies addressed some of the non-ideal characteristics of the LED emissions. Measurements of CO and CO2 were conducted using their fundamental absorption bands centered at 4.7μm and 4.3μm, respectively, while a 3.6μm reference LED was used to account for scattering losses (e.g., due to soot, window deposits, etc.) common to the three measurement LEDs. Instrument validation and calibration was performed using a laboratory flow cell and bottled-gas mixtures. The sensor was able to detect CO2 and CO concentration changes as low as 30 ppm and 400 ppm, respectively. Because of the many control and monitor species with infrared absorption features, which can be measured using the strategy described, this work demonstrates proof of concept for a wider range of fast and low-cost sensors for gas measurement and process monitoring.