Self-Calibrating High Resolution Tunable Filter For Remote Gas Sensing Applications

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PROJECT SUMMARY

The objective of Phase-I work has been to design and develop a compact, robust, optically based sensor for local and remote sensing of oxygen (O_2) at 1.26 µm, carbon dioxide (CO_2) at 1.56 µm and other species in spectral region of up to 2µm. We employed acousto-optic technology for accomplishing this objective, and in that we designed and fabricated two acousto-optic devices, one an Acousto-Optic Tunable Filter (AOTF) and the other an Acousto-Optic Deflector (AOD). We studied and characterized performance of these devices, and further demonstrated that using these active Acousto-Optic devices in conjunction with a diffraction grating it is possible to achieve a wideband tunable filter with spectral bandwidth resolution << 200pm. Further, during Phase-I we also addressed Lidar gas sensing applications where it is desirable to have passive filters with enhanced filter properties for efficient suppression of background radiation outside the signal bandwidth in order to achieve sufficiently high SNR. To address these situations where passive filters are of interest we studied and devised two attractive schemes involving Fabry-Perot talons and fiber Bragg gratings.

Major goals achieved in this Phase I SBIR are as follows:

(i) Designed, fabricated, and characterized an AOTF
(ii) Designed, fabricated, and characterized an AOD
(iii) Procured a Diffraction Grating DG and characterized.
(iv) Studied and demonstrated achievable spectral bandwidth of an AOTF-grating combination < 200 pm.
(v) Studied convolution-deconvolution schemes and established possibility of reducing spectral bandwidth in the order of sub-100pm.
(vi) Demonstrated sufficient beam deflection achievable by AOD to compensate beam deflection caused by AOTF-grating combination. This demonstration ensures it is possible to assemble an AOTF, a DG and an AOD to accomplish a tunable narrowband filter where the output beam direction remains unchanged as the wavelength is changed, allowing use of a single detector for signal detection.
(vii) Studied and devised schemes for constructing filters to address more demanding Lidar based gas sensing applications where passive filters with enhanced filter properties including bandwidth < 100pm are of interest.

If the program goes through Phase-II we will design and develop prototype filter systems employing active and passive devices capable of offering a comprehensive solution to handle a wide variety of scenarios encountered in Lidar applications.