NASA SBIR 2006 Phase I Solicitation

S6.02 Lidar System Components for Spaceborne and Airborne Platforms

Lead Center: LaRC

Participating Center(s): GSFC

High spatial resolution, high accuracy measurements of atmospheric parameters from ground-based, airborne, and spaceborne platforms require advances in the state-of-the-art lidar technology with emphasis on compactness, reliability, efficiency, low weight, lifetime, and high performance. Innovative technologies that can expand current measurement capabilities to airborne, Unmanned Aerial Vehicle (UAV), or spaceborne platforms are particularly desirable. Development of components that can be used in actual deployed systems within the next few years is highly encouraged. Technologies and components that are not clearly suitable for effective lidar remote sensing or field deployment are not applicable to this subtopic. This subtopic considers components that enable Earth-sun system measurements such as:

- Cloud and aerosols with emphasis on aerosol optical properties;
- Wind profiles using direct-detection (noncoherent) lidar, or coherent-detection (heterodyne) lidar, or both;
- Land topography (vegetation, ice, land use); and
- Molecular species (carbon dioxide, ozone, and water vapor).

Innovative component technologies that directly address the measurement needs above will be considered. Dual-use technologies addressing Planetary Exploration are highly desirable. This subtopic is soliciting only the specific component technologies described below.

1. Pulsed, single frequency, diode laser or fiber laser based seeded MOPA systems are desired due to inherent robustness, efficiency, thermal and alignment stability. If the cost per unit is reasonable, and the size is small, then many of these can be installed on a spacecraft for either parallel operation or as backup units to lengthen the life of the mission. Systems with the following specifications are solicited:
- Stable single frequency operation at 1047nm, 1064 nm, or 1570 nm;
- Small, integrated assemblies that can generate CW powers in the 100's of mW to several Watts range and higher peak power pulsed operation yielding at least 10 to 500 nJ pulse energies;
- Fiber laser and amplifier designs with high SBS suppression;
- Gaussian pulsewidths between 100 ps and 50 ns;
- MOPA design configuration is desired where the pulse production cavity is short and more readily impedance matched for the fast rise times, gain switching, etc.;
- A semiconductor amplifier, or possibly a small cm-scale rare Earth doped fiber amplifier, can be coupled to the oscillator chip's output, itself contained in a hermetic butterfly or similar package;
- Repetition rates as low as 100 Hz and as high as 10 kHz are needed, with pulsed lifetimes in the trillion shot regime ($10^{12}$);
- Single mode, polarization maintaining (PM) fiber output is needed;
- Short term drift less than 1 MHz;
- Second and third harmonic generation techniques that can be packaged with the CW and pulsed diode or fiber laser sources to produce additional wavelengths in the visible or ultraviolet.

2. High speed fiber multiplexers for single and multimode fiber. A 1-to-10, or greater, multiplexer that is capable of switching on the order of 10 to 100 kHz with low insertion losses is required. Unit must be small, lightweight, and use little power. Single mode fiber version must be capable of handling high power (>100 microJoules at 10 kHz at 1064 nm). Multimode version will be used in low power applications and must be compatible with 0.22 NA fiber with 100 to 600 micron core size. Switching speeds faster than 10 microseconds are required.

3. Efficient and compact single frequency solid state or fiber lasers operating at 1.5 and 2.0 micron wavelength regimes suitable for coherent lidar applications. These lasers must meet the following general requirements: pulse energy 2 mJ to 100 mJ, repetition rate 10 Hz to 200 Hz, and pulse duration of approximately 200 nsec.

4. Single element, low noise, high quantum efficiency, HgCdTe avalanche photodiode detector (APD) capable of photon counting at rates >10 MHz for use in the 1570 nm range. Should be suitable for operation with a thermal electric cooler.

5. Lightweight compact lidar telescopes operating at one or more of the primary laser wavelengths in 1.0 to 2.0 micron wavelength region. The general requirements are: optical quality better than 1/6 wave at 632 nm, mass density less than 12 kg/m$^2$, and aperture diameter from 10 cm to 30 cm. Proof of scalability to 50 to 75 cm diameter for deployment in space is required.
6. Interferometric lidar aft-optics receiver subsystems/components to separately derive aerosol and molecular backscatter via High Spectral Resolution Lidar (HSRL) technique. The subsystem/component is to be implemented into a HSRL system with the goal of independently derive aerosol backscatter and extinction. Subsystems/components are needed at 355 and 532 nm wavelengths. Architectures could be based on Fabry Perot, Mach Zehnder, or other interferometric implementations. Resolving power of the order of 1 GHz and high frequency stability of pass/stop bands are required. Concepts must address issues associated with etendue of large-aperture (1 - 1.5 m) lidar receivers with field of view of the order of 200 micro-radians.

7. CCD detectors with high quantum efficiency at 355 and 532 nm for spaceborne lidar instruments measuring cloud and aerosol backscatter and extinction. CCD detectors are needed to replace single element PMT detectors for imaging fringes from interferometric elements of a HSRL instrument. Clocking schemes to move charge on the CCD to achieve on-chip profile averaging and reduce dark current and readout noise should be considered.