NASA SBIR 2005 Phase I Solicitation

S6.02 Lidar Remote Sensing

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, and high performance. Innovative technologies that can expand current measurement capabilities to airborne, spaceborne, or Unmanned Aerial Vehicle (UAV) 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 lidar, or coherent-detection (heterodyne) lidar, or both;
- Land topography (vegetation, ice, land use); and
- Molecular species (ozone, water vapor, and carbon dioxide).

Innovative component technologies that directly address the measurement needs above will be considered. Dual-use technologies addressing Planetary Exploration are highly desirable (see subtopics X1.03 and S1.04). For the PY05 SBIR, we are soliciting component technologies described below.

- Pulsed, single frequency, diode-based seed laser 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:
  - Single frequency 1064 nm operation.
- Small, pinned package(s) that can generate CW powers in the 100's of mW and higher pulse powers yielding at least 10 nJ pulse energies.

- Gaussian pulsewidths between 100 ps and 5 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 Yb: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 is needed, with pulsed lifetimes in the trillion shot regime ($10^{12}$).

- Single mode, PM fiber output is needed.

- Short term drift less than 1 MHz.

- **CW, dual frequency, diode-based seed laser systems are desired for high power solid-state laser cavity feedback and locking at 1064 nm. If two wavelengths are produced, one must be 1064 nm and another single wavelength 5 nm or more offline (in either direction). Systems with the following specifications are solicited:**

  - Simultaneous dual frequency operation: 1064 nm and a second wavelength at least 5 nm (either plus or minus) from 1064 nm.
  
  - Small, pinned package(s) that can generate CW powers in the 100s of mW and higher pulse powers.
  
  - CW output powers of >10 mW in each wavelength. Individual tunability is not required, but tunability of the 1064 nm output is required.
  
  - Dual PM, single mode fiber output is desired, but not absolutely required.
  
  - 5 MHz or less short term drift over 30 sec.

- **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.**

- **Shared aperture, angle-multiplexed holographic or diffractive optical elements having several fields of view, each with angular resolution of 50 µrad or better for the Nd:YAG or Nd:YLF laser harmonics, and diffraction limited resolution for the Ho:YLF fundamental wavelength. Wide, flat, focal planes with low off-axis aberrations is of importance to terrain and vegetation mapping lidar applications. Hybrid designs using both 2053 nm or 1064 nm and 355 nm simultaneously are needed for dual wavelength Doppler wind lidar applications. Materials and technologies are needed that can be scaled up to 1 m apertures and larger and space qualified. Designs using lightweight materials, such as composites or membranes and deployable folded architectures, are also desired to decrease system size and weight.**

- **Novel, high-power laser diodes capable suitable for pumping Holmium-based solid state lasers:**
- Quasi-CW laser diode arrays operating in 1939 nm or 1906.8 nm wavelengths with pulse duration of at least 1 msec, peak power in 10s watts regime, and duty cycle of greater than 2%;

- Quasi-CW fiber-coupled laser diode pump arrays operating in 785 nm or 792 nm wavelengths with pulse duration of at least 1 msec, peak power in 100s watts regime, and duty cycle of greater than 2%; and

- CW fiber-coupled laser diode pump arrays operating in 1939 nm or 1906.8 nm wavelengths.

- 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/m², and aperture diameter from 10 cm to 30 cm. Proof of scalability to 0.5-1.0 m diameter for deployment in space is required.

- Laser beam steering and scanning technologies (such as dual-wedge, diffractive optical elements, and liquid crystal) operating at 1.5 or 2.05 micron with 2 cm to 25-cm aperture diameter meeting the following requirements:

  - 60 deg. field of regard.
  - 90% optical throughput.
  - 1/4-wave single pass optical quality at 632 nm.