NASA SBIR 2004 Phase I Solicitation

E1.02 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 techniques, components, and instrument concepts 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, subsystems, and complete instrument packages addressing the following specific measurement needs:

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

In addition to instrument systems, innovative component technologies that directly address the measurement needs above will be considered. Technical and scientific leads at NASA have given careful consideration to the component technologies described below, and responses are solicited for these technology areas.

1. Novel laser materials and components for high efficiency solid state lasers operating at 1 and 2 µm wavelength regions. The laser components include:

   - Rugged, compact fiber lasers and fiber amplifiers for use at 1.5 and 1 µm;
• Low voltage (Efficient and reliable high power, quasi-CW, pump diodes operating at 792 nm and 808 nm in fiber-coupled or free-space configuration; and

• Laser crystals for generating 2 µm radiation with high thermal conductivity and small variation of the index of refraction with temperature.

2. High damage-resistant, efficient, inorganic and birefringent nonlinear optical materials for generation of ultraviolet and mid-infrared radiation.

3. Thermally efficient conductively-cooled head for solid-state lasers with side-pumped rod configuration, and thermally and mechanically stable optical bench.

4. Frequency-agile, semiconductor lasers operating in 1 to 2 µm wavelength region with spectral linewidth less than 200 kHz over 1 ms and optical power greater than 20 mW.

5. Scanning or scanable lightweight telescopes with an optical quality better than 1/6 wave at 632 nm, mass density less than 12 kg/m², and aperture diameters from 0.5–1.0 m.

6. Laser beam steering and scanning technologies operating at 0.355, 1.06, or 2.05 µm with 5–25 cm aperture diameter for airborne and 0.5–1.0 m for spaceborne instruments, meeting the following minimum requirements:

   • 60° field of regard
   • 90% optical throughput
   • wave single pass optical quality at 632 nm

7. 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.

8. High gain, low noise photon counting detectors that operate without the use of cryogens are needed. Other desirable properties are linearity over a large dynamic range, saturation count rates over 100 MHz, reasonable active area size (>200 µm), 250–2200 nm response wavelengths, and high clocking and readout rates with low read noise. High-speed (500 Msamples per second or greater) waveform digitizers are also of interest for operation with integrated pulse-finding capability suitable for continuous operation and capable of locating more than 200,000 individual pulses per second.
9. Narrow band optical filters with 75% throughput, with minimum 1 inch clear aperture.