reflected light from the measurement region to be received from the planar measurement region and diverted along a vertical path to a photoreceiver arrangement.

US 7,746,449 discloses a light detection and ranging system, comprising a collimated laser beam, a mirror unit rotating around a scan axis, the mirror unit including a receiving portion and a transmitting portion offset by an angle about the scan axis relative to a surface plane of the receiving portion, respective centroids of the receiving and transmitting portions being positioned at a common point on the scan axis.

US 7,969,558 discloses a lidar-based 3-D point cloud system comprising a support structure, a plurality of laser emitters supported by the support structure, a plurality of avalanche photodiode detectors supported by the support structure, and a rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM (rotations per minute).

US application 2011/0216304 discloses a LiDAR-based sensor system comprising a base, head assembly, a rotary component configured to rotate the head assembly with respect to the base, the rotation of the head assembly defining an axis of rotation; an electrical motherboard carried in the head assembly, the motherboard defining a plane and being positioned substantially parallel to the axis of rotation, a plurality of photon transmitters mounted to a plurality of emitter circuit boards, the plurality of emitter circuit boards being mounted directly to the motherboard, and a plurality of detectors mounted to a plurality of detector circuit boards, the plurality of detector circuit boards being mounted directly to the motherboard.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a time-of-flight lidar apparatus comprising: a single optical emitter sensing in one dimension; at least one photodetector; a mechanical means of scanning in two dimensions said emitter and at least one photodetector.

According to a second aspect of the present invention, there is provided a method for three-dimensional sensing utilizing a time-of-flight lidar apparatus comprising: a single optical emitter sensing in one dimension; at least one

photodetector; a mechanical means of scanning in two dimensions said emitter and at least one photodetector.

An apparatus and method are used for three-dimensional sensing with a time-of-flight lidar sensor having a single emitter and at least one photodetector. Said single emitter can comprise a single laser, a single laser bar, or multiple lasers (preferably in the form of an integrated multi-laser chip, or co-packaged laser chips, or a multi-chip module in a single package), and in all three cases the emitter output is imaged to form a radiation pattern whose envelope is elongated to provide one-dimensional sensing. Said single emitter can also comprise a single laser coupled to

an optical phased array (OPA) that either images a radiation pattern whose envelope is elongated to provide one-dimensional sensing, or sweeps a beam in one dimension to provide one-dimensional sensing. Said single emitter can also comprise a single laser coupled to a diffractive optical element (DOE) or a holographic optical element (HOE), with either optical element imaging a radiation pattern whose envelope is elongated to provide one-dimensional sensing. For all single emitter configurations, a mechanical motion (e.g., spinning or mirror/prism/lens/DOE/HOE/grating scanning) is used to cover the two dimensions not covered by the emitter, resulting in three-dimensional sensing.

When a plurarity of photodetectors are used, they preferably comprise an integrated multi-photodetector chip, or co-packaged photodetector chips, or a photodetection multi-chip module.

Photodetector types include single-photon avalanche diode (SPAD) arrays, avalanche photodiodes (APD) and PIN diodes (PIN diodes are positive-intrinsic-negative diodes, as they comprise a lightly-doped intrinsic semiconductor region between a p-type or positive-type semiconductor region and an n-type or negative-type semiconductor region).

As opposed to US 5,455,669 and US 7,746,449, the apparatus according to embodiments of the present invention does not have a static collimated laser in the dimension normal to the plane covered by the mechanical motion, but instead has an emitter than covers said normal dimension through imaging a radiation pattern whose envelope is elongated or through sweeping in said normal dimension.

As opposed to US 7,969,558 and US application 2011/0216304 where the described apparatus comprises a plurality of emitters, the apparatus according to embodiments of the present invention comprises a single emitter. Also, as opposed to APDs, the present invention can use PIN diodes or preferably SPAD arrays. Furthermore, the head assembly is static as opposed to rotating, and only the internal turret is spinning when the mechanical motion consists of spinning, or an optical element (e.g., mirror, prism, lens, DOE, HOE, grating) is scanning when the mechanical motion consists of scanning. The entire external body of the lidar in the present invention is static.