

Beam Steering Devices Reduce Payload Weight

NASA Technology

Scientists have long been able to shift the direction of a laser beam, steering it toward a target, but often the strength and focus of the light is altered. For precision applications, where the quality of the beam cannot be compromised, scientists have typically turned to mechanical steering methods, redirecting the source of the beam by swinging the entire laser apparatus toward the target.

Just as the mechanical methods used for turning cars has evolved into simpler, lighter, “power steering” methods, so has the means by which researchers can direct lasers. Some of the typical contraptions used to redirect lasers are large and bulky, relying on steering gimbals—pivoted, rotating supports—to shift the device toward its intended target. These devices, some as large and awkward as a piece of heavy luggage, are subject to the same issues confronted by mechanical parts: Components

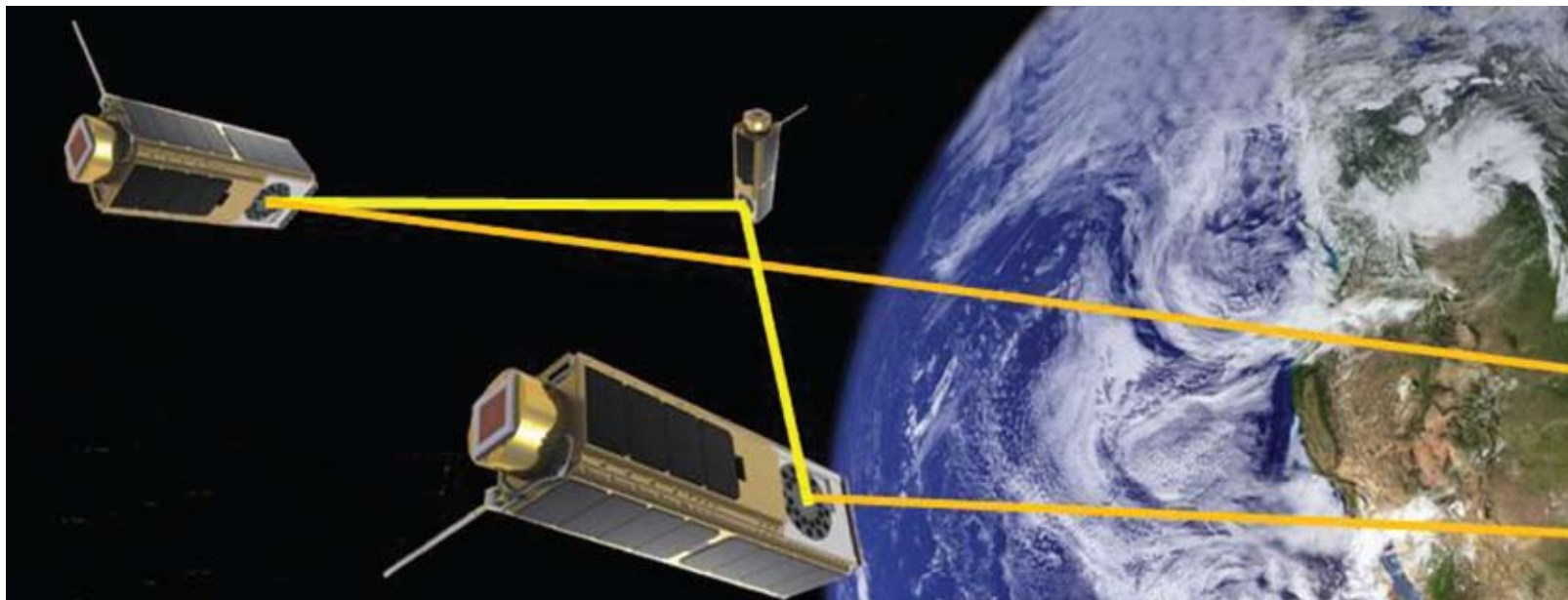
rub, wear out, and get stuck. The poor reliability and bulk—not to mention the power requirements to run one of the machines—have made mechanical beam steering components less than ideal for use in applications where weight, bulk, and maneuverability are prime concerns, such as on an unmanned aerial vehicle (UAV) or a microscope.

The solution to developing reliable, lighter weight, nonmechanical steering methods to replace the hefty steering boxes was to think “outside the box,” and a NASA research partner did just that by developing a new beam steering method that bends and redirects the beam, as opposed to shifting the entire apparatus. The benefits include lower power requirements, a smaller footprint, reduced weight, and better control and flexibility in steering capabilities. Such benefits are realized without sacrificing aperture size, efficiency, or scanning range, and can be applied to myriad uses: propulsion systems, structures, radiation protection systems, and landing systems.

Partnership

Through Small Business Innovation Research (SBIR) contracts with both Johnson Space Center and Langley Research Center, Boulder Nonlinear Systems Inc. (BNS), of Lafayette, Colorado, developed a solution to some of the problems of mechanical beam steering, using advanced optical phase array (OPA) chips. Instead of changing the direction of the entire device, OPA chips allow the beam itself to be deflected and thus redirected. The high-resolution, high-speed, fully programmable system developed by BNS shows promise not only for NASA research needs, but for a variety of commercial and industrial needs as well.

While OPA chips are not new technologies, appearing first in the 1980s, BNS worked to improve both the construction and functionality. Before teaming up with NASA, the company had been working with the University of Colorado’s Optical Computing Center,



This computer rendering shows one possible application for the optical phase array (OPA) technology developed by Boulder Nonlinear Systems Inc. (BNS) through the SBIR program. The rendering shows laser communication using NASA's Organism/Organic Exposure to Orbital Stresses, or O/OREOS nanosatellites.

one of the National Science Foundation's Centers of Excellence, to develop new chip technologies.

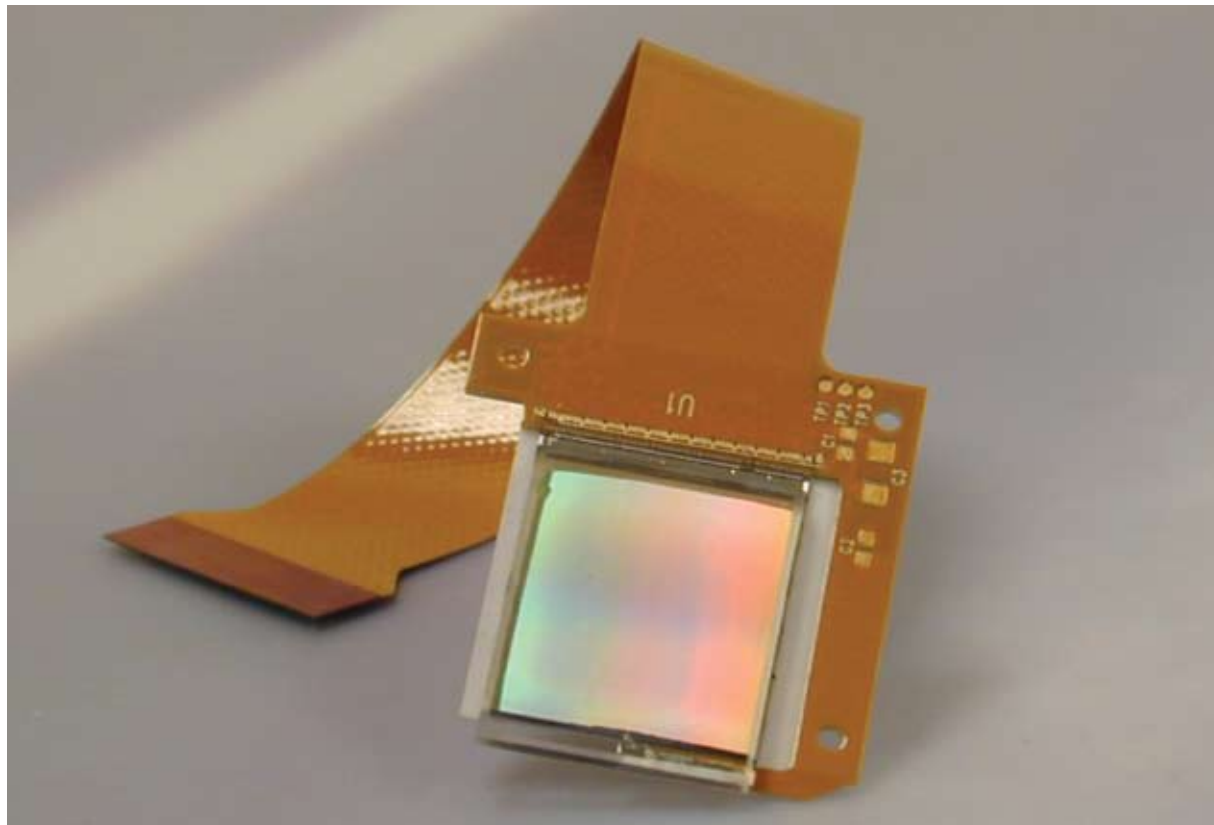
Through its first two NASA SBIRs with Johnson in the early 1990s, BNS began experimenting with liquid crystals on silicon (LCOS) chips, creating a functional OPA, but one that was limited in usefulness as a steering component due to a small aperture and low voltage operation. The company continued work on the project with a 2002 Phase II SBIR with Langley to develop high-speed, high-resolution, fully programmable, nonmechanical beam steering. Within two years, BNS had completed the project, developing an OPA chip capable of driving high-speed liquid crystal phase modulators.

Benefits

The OPA chips combine high-speed liquid crystal phase modulators and high-voltage, very large scale integration (VLSI) silicon back planes that contain thousands of integrated, transistor-based circuits created through the VLSI foundry process. The transistor-based circuits transmit high-voltage signals to the liquid crystal components, reorienting the liquid crystals. This reorientation alters the modulator's refractive index, creating a phase modulation that allows the beam to be shifted or deflected with a great deal of control and very fine resolution.

The use of the higher voltages allows faster crystal response times and faster beam steering. The uniformity and flatness of the OPA chips also enables more accurate and precise steering. Together, these features combine to allow for a compact, low-power, lightweight OPA chip that provides better control of the steering along with increased flexibility.

These new OPAs have applications across fields as varied as scientific research, aeronautics, defense, telecommunications, and biomedical engineering. In the biomedical field, the devices help to improve pulse shaping for photon microscopy for researchers working on early detection of Alzheimer's disease and certain cancers.



The liquid crystal on silicon OPA chip from BNS enables accurate and precise laser beam steering. Together, its features create a compact, low-power, lightweight OPA chip that provides improved control of the steering along with increased flexibility for applications in a variety of areas.

According to Steve Serati, president of BNS, "Researchers use the device to improve their ability to view biological samples, thus enabling early detection of some diseases."

Large aerospace and defense contractors like Northrop Grumman use the devices for military sensing and ground avoidance. The arrays are also helping to develop improved laser imaging and light detection and ranging capabilities along with laser-sighted weaponry. This technology also has applications in forensics and other areas that can benefit from finer resolution and larger views

of microscopic samples. Because of the lower weight of the arrays and decreased energy consumption required to move the beam, the OPAs have been incorporated into satellite-based systems.

Serati estimates that BNS's NASA-derived devices have been used by nearly all of the major aerospace companies and over 100 research laboratories across governments, private sectors, and universities—and he expects this number will continue to grow. ❖