"FUTURE APPLICATIONS"

Lasers are a transformative technology and play a significant role in daily life today. With seemingly limitless potential, current R&D efforts show outstanding promise for lasers to be the backbone for the development of tomorrow's more effective and efficient healthcare, energy, commerce and communications solutions.

I. Lasers Enhance Medicine and Biology

With much emphasis on the rapid growth in this market beyond cosmetic and eye surgery, analyst predictions indicate that this market will exceed $740 million by 2013*.

1. Laser-based medical imaging
   New medical imaging technology, such as optical coherence tomography, allows doctors to shine laser light to image within living tissues and detect problems like breast cancer or retinal diseases. Improvements to these technologies will allow broad adoption in the medical profession, leading to earlier detection of life-threatening diseases.

2. Lasers for earliest disease diagnosis
   In addition to imaging, lasers are being used in a variety of ways to identify diseases at their earliest stages and help physicians begin treatment earlier. For example, clinical trials are starting for a laser-based technique that will identify Alzheimer's disease decades before symptoms begin. Promising studies also have looked at laser technology for breath analysis to diagnose cancer and asthma by simply sampling breath from an exhale; stimulated emission microscopy to beat diffraction limit; remote detection of bacteras, virus, other biomollecules exciting biomarkers of various types/uses; etc; photoporation – transfer of exogenous DNA into cells.

3. Laser-based cancer treatment
   By directing gold nanoparticles – metal structures that measure just one billionth of a meter – into cancerous tumors using monoclonal antibody technology, then illuminating them with laser light, scientists have developed a way to destroy malignant cells, while normal cells remain intact – a feat not possible with today's radiation and chemotherapy cancer treatments. In the future, this nanoscale work in human cells could lead to targeted disease therapies – attacking cells that show the initial signs of becoming cancerous growths, for example – at stages before symptoms present. Use of DOT for neoadjunctive chemo and leaky tumor vasculatory detection; probing and following dyes attached to cancer cells; direct detection of cancer stem cells (which look very much like normal cells). Tracking stem cells in vivo-examine formation, life, where they are formed.

4. Lab-on-a chip
   Miniature laser-based laboratory-on-a-chip sensor-systems allow detection of a wide range of physiological parameters (blood count, blood sugar level, PT/INR, oxygen level, heart rate, alcohol level, etc.). These chips may be embedded beneath the skin and interrogated with a wand reader to provide vital medical statistics of patients on a real-time basis.

**All analyst predictions are courtesy of laser-industry firm, Strategies Unlimited.*

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II. Lasers Boost Energy Applications

Laser fusion is in its infancy right now, but as research develops, there is the potential for laser technology to become a significant economic contributor in alternative energy. Similarly, laser technology will play a large role in emissions and environmental monitoring.

1. Laser fusion
   The Department of Energy's Lawrence Livermore National Laboratory is conducting tests at its National Ignition Facility to develop the world's largest laser system, which will open the door to laser fusion – providing a sustainable, carbon-free alternative energy source.

2. Lasers for transportation and emissions
   Researchers are working to replace traditional combustion engines with laser-based ignition to increase fuel efficiency and reduce harmful emissions. In addition, beamed energy propulsion (BEP) is on track to radically transform the future of air and space transportation.

3. Environmental sensing with lasers
   Laser techniques, including spectroscopy, can take in readings of environmental impurities, helping to keep a handle on emissions, water pollutants and other concerns. As it becomes more widespread, such monitoring will enable stricter standards and earlier notification of environmental contaminants, allowing for quicker clean-up and less negative impact.

III. Lasers Improve Commerce, Manufacturing and Production

Lasers offer solutions manufacturing processes that speed up production and cut costs and have yet untapped potential for scanning and monitoring cargo. With more and more interest in this area, projections expect this market to achieve $3 billion by 2013.

1. Lasers for manufacturing
   New developments are enabling lasers to cut through three inches of solid steel in mere seconds, expediting manufacturing processes. High-power fiber lasers promise faster, more precise and efficient cutting, welding and marking for instance, making 3-D prototypes (models) in plastic.

2. Inspecting inbound and outbound packages
   Laser techniques, such as laser generated gamma rays or TeraHerz radiation, will enable us to look inside dense objects and monitor cargo transport, determining the presence or absence of a nuclear substance without opening. There are widespread implications for quicker and more efficient shipping, as well as for security monitoring purposes such as remotely detect surface contamination like explosive detection, content leakage, etc.

IV. Lasers Transform Electronics, Computing and Communications

As the demand for high-speed broadband continues to grow and companies identify ways to create a connected world, the communications infrastructure enabled by lasers continues to climb. Looking at 2013, industry analysts are slating this market to expand to near $3 billion.

1. All-optical fiber communications
   Current fiber optic technology (such as Verizon's FiOS), uses both optical (laser-based) and electronic technology to bring the Internet and cable into homes and businesses. Researchers

are developing new fiber optic technology that will someday be entirely laser-based, providing unprecedented speed and data capacity, well in excess of Tbps data rates over a single strand of fiber.

2. Completely secure networks Quantum encryption involving lasers has the potential to completely safeguard Internet connections. This laser-based technology will provide protected online transactions, helping to negate identity theft and other security breaches. Quantum encryption holds tremendous promise for secure online information exchange.

3. Smart Materials
   Bridges, aircraft wings and other structures built with embedded fiber-optic strain sensors will allow detection of impending structural failure.

4. Laser free space communications – between satellites, deep space probes, etc.

V. Lasers Allow Scientists to Peer into the Unknown

Entirely new research capabilities are being enabled by lasers that allow scientists to study physics processes that cannot be studied in other ways.

1. Gravitational Wave Detection
   The NSF funded Laser Interferometer Gravitational Observatory (LIGO) and the NASA Laser Interferometer Satellite Antenna (LISA) will enable detection of gravity waves for the first time and provide details of the first moments of the creation of the universe as well as astronomical events such as Hulst-Taylor neutron star inspirals and black hole formation.

2. Relativistic Collision Studies
   The exceptionally high fields associated with intense short pulse lasers make possible studies of relativistic collisions of particles traveling near the speed of light.

3. Archeology
   Fossils, ancient textiles and even medieval art will be analyzed using lasers to uncover their composition. For example, laser diagnostic techniques make possible the identification of still intact dinosaur proteins. Paintings by DaVinci, when illuminated by infra-red lasers, have been shown to contain earlier undiscovered artwork beneath.

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