Technology Focus

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LASER TECHNOLOGIES - II

Laser Equipment

From the Desk of Guest Editor

First issue of "Laser Technologies" covered the indigenous Laser Sources and associated technologies developed/being developed at LASTEC. LASTEC also has the mandate to develop electro-optic countermeasure and battlefield optoelectronics equipment for defence and low intensity conflict operations.

LASTEC is working on the development of laser based equipment for wide spectrum of applications like Safe Ammunition Disposal, Optical Dazzling, Optical Target Location, Detection and Identification of Chemical and Biological Agents and Explosive material, High Value Assets Protection, Laser Warning and Countermeasures and PGM Test and Evaluation Systems.

Over the past few years, DRDO has developed core competence in optical and embedded design for laser based equipment.

This special issue of Technology Focus highlights the various laser equipment developed at LASTEC and the infrastructure facilities available for their test and evaluation.

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LASER EQUIPMENT

DRDO has developed various laser equipment which may be of use for Three Services and Police Forces for Low Intensity Conflict (LIC) operations. Laser Ordnance Disposal System (LORDS) and Light Detection and Ranging (LIDAR) equipment have been developed for land forces. PGM test equipment such as IR Guided Missile Tester and Griffin LGB Kit Tester have been developed and may be used by IAF as import substitution. Laser Projection System and Laser Countermeasures are being developed for the Indian Air Force. Laser Cross Section Measurement and Imaging (LACSMI) technology is being developed for Naval applications. Laser dazzlers, Electro-optic Target Locater (OTL) and chemical, biological and explosive material detection equipment have been developed for counter LIC operations.

Laser Ordnance Disposal System

Laser Ordnance Disposal System (LORDS) is meant for the disposal of explosive devices like surface laid unexploded ordnances, mines, directional mines, and IEDs from a safe stand-off distance by focusing laser energy onto munitions casing thereby heating it until the explosive filler ignites and start burning. The combustion of explosive charge leads to low level detonation or deflagration of explosive device. The advantages of using laser to dispose munitions are safe stand-off ranges for personnel, ultra precision, fast disposal and reduced collateral damage.

The engineered prototype of laser source along with its support equipment is mounted on TATA-LSV vehicle for standalone operation. Laser optics module integrated with motorised beam director assembly and high range accuracy laser range finder assisted auto focusing system, mounted on a two axis servo pedestal is used for precise pointing and directing high power laser beam on to the target. A CCD camera with variable zoom, integrated and bore sighted with laser unit is used for target sighting. A visible laser beam is provided for aiming the hit point on target. The operation of system is controlled by a single operator through a command control console provided in front of co-driver seat.

The system comprises of five subsystems: Laser Device (LD); Beam Control System (BCS); Thermal Management System (TMS); Fire Control System (FCS) and Prime Power Unit (PPU). The heart of the system is a kW class fibre laser which produces the desired energy for disposal of ordnance. The BCS comprises of a beam director mounted on a servo pedestal. The system incorporates zoom camera bore sighted with beam director and a bore sighted laser range finder for auto focusing of beam on to ordnances. The TMS is responsible for the removal of heat dissipated in laser head. The FCS consists of

Ordnances Tested and Neutralised by LORDS a computer, control electronics unit, display, joystick, recording device and other equipment required to control and monitor the operation of system. The PPU supplies electrical power for various sub-systems. The integrated system can be operated through Remote Control Unit (RCU).

Laser device used in the system is kW class fiber laser operating at 1070 nm. The aiming laser operates at 532 nm.

The experimental trials on LORDS were jointly carried out with ARDE and TBRL for evaluating system potential and capabilities at Ramgarh Range, Chandigarh. The trials were conducted on low and medium caliber ordnances from stand-off ranges of 150 m and 250 m. About 13 different types of ammunitions had been tested and more than 45 disposals had been conducted till date. This includes:

- Surface mines - M14 A/P mine, directional mine
- Ordnances - 30 mm grenades, hand grenades 36 M, 51 mm mortar bomb, 81 mm mortar bomb
- IEDs - traveler sack, transistor, tiffin box, toy, suitcase
- Anti tank- Influence mine MK-1, bar mine

DRDO is now developing an upgraded system to dispose of higher calibre ammunition.

TATA - LSV Mounted LORDS

Optical Target Locater

Infrared (IR) lasers have emerged as important candidates for covert laser surveillance as well as for sanitisation of specific area. As any hostile action is always preceded by an optical observation, detection and location of any threat gives a tactical advantage to the security and armed personnel to take prior defensive or offensive measures.

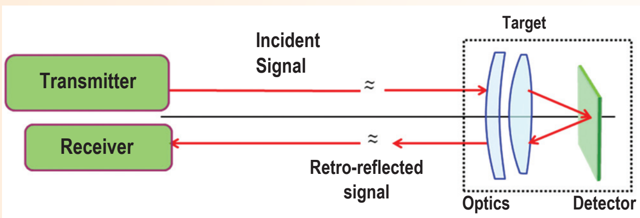
LASTEC has developed an Optical Target Locater (OTL 300) for the detection of a passive or active optical threat for operational ranges of snipers. The system functions on Cat's eye effect. Any optical system when illuminated by a laser beam returns some back scattered energy. This retro-reflected energy provides the location of the optical target against the background.

The system provides an important tool for detection of any active or passive surveillance device using the retro-reflected signal from their front end optics. The threat can be in the form of a sniper equipped with a day sight or a night vision device, or any other optical/electro optical surveillance device, viz., binoculars, surveillance cameras, laser range finders, designators, etc.

An OTL comprises of a laser transmitter and a laser receiver for detection and location of the target. The laser transmitter comprises of a pulsed IR eye safe laser source producing a homogeneous laser beam of required divergence for generating the desired spot size at the distant target.

The receiver of the system comprises of a high sensitivity imaging sensor with peak spectral sensitivity at the design wavelength, and front end imaging optics for high quality imagery.

The read out electronics of the sensor is configured for video display of the scene viewable through the monocular. Digital signal processing techniques are used for image contrast enhancement.



Conceptual Diagram of Optical Target Locater

The system operation relies on press button operation at operator's discretion. For system operation, the operator energises the imager for area surveillance and then activates the pulsed divergent laser to precisely point within the sensor FOV.

Any optical target looking towards the system will produce a bright retro-reflected spot against the background that can be directly viewed by the operator through the monocular leading to target detection and location.

In OTL 300, both the target and the background are clearly visible for estimation of target location. Since target detection through the OTL is based on achieving high contrast between the retro-reflection from the front end optics of the optical threat and the background scene, the system parameters have been optimised to achieve high contrast between the retro-reflected signal and the background.

The system is robust, lightweight, compact and user friendly for efficient operation. Equipment with capabilities of higher ranges, network ready operations are also being developed.

Optical Target Locater (OTL 300)

Targets Detected with OTL

Laser Dazzler

In recent years, the laser dazzler systems have evolved as highly potent threat deterrent for area denial. The conventional means of dispersing or controlling an agitated crowd can cause serious and lethal injuries. Laser dazzler which transmits a laser beam in visible spectrum temporarily impairs or disorients the aggressors in a completely non-lethal manner.

Laser dazzlers are non-lethal weapons specifically designed for applications where subject vision impairment must be achieved at specified distance in all ambient conditions including clear sunny day, twilight and night. Laser dazzlers can be configured for variety of configurations from hand held to weapon mountable to vehicle mountable.

LASTEC has developed variants of laser dazzler for diverse applications. Laser dazzlers from a range of a few tens of meters to tens of kilometers have been developed. Long range laser dazzler (Helios-AD) is a concept demonstrator prototype for dazzling at ranges of tens of kilometers.

The system employs EO payloads mounted on two axis gimbal for target detection, identification and

Helios-AD on Stallion

tracking for ranges in excess of 10 km. The system launches a preliminary warning to the threat using low power modulating lasers. If the threat proceed in the same direction despite warning, highly intense yet safe dazzling green laser hails the threat platform forcing it to maneuver the platform in alternate direction.

The system is integrated on mobile platform (Stallion).

Short Range Laser Dazzler

Vehicle Mounted Laser Dazzler

Sensing of Chemical, Biological and Explosive Agents

In present scenario, due to increased terrorist activities; threat to military personnel and civilians could potentially appear in the form of chemical and biological warfare and explosives. Minimising the impact of such threats requires early detection of these hazardous agents from a remote distance.

Laser spectroscopy is a powerful technology for homeland security for detection and identification of hazardous agents.

Chemical Agent Detection

The technique of Light Detection and Ranging (LIDAR) has been used since 1930. With the development of lasers in 1961, this technique gained lot of importance, as laser based systems employing pulsed lasers are highly sensitive and can detect extremely low concentrations of different chemical species present in the atmosphere at distances of several kilometres with very high degree of discrimination among molecules of different species. The unique characteristics of lasers offer significant improvements in terms of length of range, detection limits and species selectivity as compared to weaker broadband optical sources. Very high degree of monochromaticity in laser beams is responsible for discriminating between molecules of chemical agents having closely spaced transition lines in the absorption and emission spectra. High degree of wavelength tunability over a wide spectral range coupled with fast frequency agility in lasers can detect and identify large number of agents in real time. Very low divergence laser beams can pinpoint small region of clouds of interest at very long distances.

High energy pulses of laser beams are responsible for detecting species at very long distances of several kilometres in the atmosphere. Q-switched laser with pulse widths of the order of few nanoseconds can provide high degree of accuracy in the range resolved measurements.

It has been proved that Differential Absorption LIDAR (DIAL) has highest potential as a stand-off technique to detect toxic chemicals present in the

Stallion Truck Mounted Differential Absorption LIDAR atmosphere. CO_2 lasers (emitting at λ = 9-11 μm) have been commonly used for the detection of chemical agents, as it covers the desired wavelength region.

The OPO technique is used to generate tunable mid IR laser in the spectral band 2-5 μm, which is also used as a transmitter in the DIAL system. LASTEC has been working on design and development of differential absorption LIDAR based on tunable IR laser technology both in 3-5 μm, using solid state laser technology and 9-11 μm, using gas laser technology for detection of variety of chemical species both in aerosol and vapour form at sufficient stand-off ranges.

LASTEC has designed and assembled two differential absorption LIDAR sensors. First one uses OPO technique based laser operational in 3-3.5 μm and the second one uses a tunable TEA CO_2 laser based system operational in 9-11μm IR band. Several chemical species (both toxic and non-toxic) which may be present in the atmosphere (naturally or disseminated artificially) have absorption lines falling within these two potential wavelength bands. Moreover, there is less atmospheric attenuation in these spectral regions which enables longer range detection capability.

Differential Absorption LIDAR Technique

DIAL is the most frequently used technique for the detection of pollutants, toxic gases and other chemical agents in the atmosphere. Two laser pulses with different wavelengths are emitted into the atmosphere for detection of the chemical species. One wavelength (λ_{on}) is tuned exactly to the centre of specific absorption line of the molecule of interest. The second wavelength (λ_{off}) is detuned to the wing of this absorption line with no specific absorption. The absorption cross-section of the molecule of interest at λ_{on} is very large as compared to that at λ_{off}. Strong return signals at both wavelength can be detected due to large Mie scattering cross-section but the return signal at λ_{on} is weaker than at λ_{off}. Knowledge of which wavelength has been absorbed (indicated by a highly depleted return signal as compared to that at other wavelengths) gives information about the specific constituent of the atmosphere. Ratio of the return signal at these wavelengths determines the concentration of the molecules of interest due to differential absorption. Finally, the time elapsed between the transmitted laser pulse and the return pulse gives information about the distance (range) at which the cloud of the chemical species is located in the atmosphere.

System Description

The DIAL system, designed and integrated at LASTEC comprises of a pulsed tunable TEA CO_2 laser, tunable in the wavelength range of 9.2 – 10.8 μm as transmitter. This fully computer controlled laser with controllable PRF can fire laser pulses as per a predefined program allowing selection of λ_{on} and λ_{off} wavelengths corresponding to the absorption spectrum of suspected target molecule.

The receiver system comprises of a beam reducing telescope (0.1X) along with focussing optics placed at its exit port which focuses the received backscattered radiation on a liquid nitrogen cooled MCT detector. A 12 bit, 10 MS/s DAQ card is used for acquiring the LIDAR return signals. The CO_2 laser beam is folded at 90^0 for transmission in the desired direction by the firing mirror positioned at the centre of entrance aperture of the receiver telescope thus allowing a co-axial configuration for the transmitter and receiver. The whole system is mounted on a vehicle to make the system transportable. The LIDAR system is deployed in a topographic target configuration for measuring the absorption at λ_{on} and λ_{off} wavelength for simulants.

Biological Agent Detection

Biological warfare is considered as one of the most serious threat to the mankind. Bio-agents can be categorised as bacterial agents, viral agents, reckettsiae, fungi, and biological toxins. Early detection and warning systems are regarded among the most sought after gadgets for homeland security.

Ultra Violet Laser Induced Fluorescence (UV-LIF) is a fast emerging technique for the development of such systems for stand-off detection.

Trolley Mounted UV- LIF LIDAR

UV-LIF LIDAR technology for the detection of biological agents using CCD optical fibre spectrometer has been developed at LASTEC. Multi Anode Photo-Multiplier Tube (MAPMT) spectrometer based and intensified CCD based UV LIDAR sensor is under development for stand-off range.

Explosive Agent Detection

Explosives and IEDs have become the most dreaded threat in today's world. Sensitive, reliable, fast and low cost sensors are required for early detection of explosives of all types. Trace detection of explosives is a big technological challenge as the available explosive particles are too low in number or the available vapour plumes are too diluted for detection at appreciable stand-off distances.

Currently, a number of technologies exist that can be used to screen people, luggage and vehicles for explosives from a close proximity by swiping the contaminated surfaces with specially manufactured sample cards and inserting them in the sample chamber of the detection equipment. But stand-off detection would be the most desirable proposition to meet any kind of situation including pre-empting of the threats in advance by covertly interrogating them from remote and safe distances. The best hope for the stand-off detection is the analysis of particulates absorbed on surfaces by using a laser to cause these explosive particulates to emit characteristic (spectral) radiation. Though there are many laser techniques available, however only a few of them have the potential for stand-off detection. LASTEC has experimented Raman scattering techniques for this application. It includes Surface Enhanced Raman Scattering (SERS); Resonance Raman Scattering (RRS); and Coherent Anti-Stokes Raman (CARS).

Laser Induced Fluorescence (LIF), Laser Induced Breakdown Spectroscopy (LIBS), Photo Acoustic Spectroscopy (PAS), Open-path Fourier Transform Infrared Spectroscopy (FTIR), and Multi-spectral Infrared Imaging are some other important techniques for the stand-off detection of explosives. Each of these techniques have certain advantages and limitations.

Raman and Pre-resonant Raman Scattering

Raman Scattering is a powerful and well established analytical technique to determine the chemical composition and identify the chemical compounds including explosives and IEDs. Raman scattered light is frequency shifted with respect to the excitation laser frequency and the magnitude of the shift is only dependent on the internal structure of the sample. This Raman shift therefore serves as the finger print of the molecule. The major limitations of Raman scattering are its weak effect and background fluorescence.

However, the problem of small Raman backscattering cross-section can be overcome if one uses a UV pump laser to excite the sample to an actual excited level instead of a virtual level. This resonance enhancement can be as high as 10^6 times the normal Raman signals and thus it can greatly improve the detection limits. Use of solar-blind UV laser wavelength (< 300 nm) allows Raman system to be used in daylight without interference from ambient light. Theoretical calculations indicate that traces of explosive vapours upto ppb levels can be detected from distances of 10 m using RRS with S/N ratio of 10 in well optimised experiments.

A large aperture receiving telescope must be used to develop high sensitive detection system. Pulsed laser excitation combined with time gated detection (CCD/ICCD) allows the system to record the prompt Raman signals from the sample and discriminate the background radiation.

Prototypes Developed

Three prototypes based on Raman and pre-resonant Raman spectroscopy have been developed at LASTEC.

First type of equipment is a handheld portable stand-off explosives detector, Pre-emptor which is successfully tested for detection and identification from stand-off distance of 30 cm to 5 m. Explosives which are in the form of liquid in transparent/ semi-transparent glass and plastic bottles, powders in transparent/ semi-transparent polyethylene bags, pills, and tablets, etc. have been tested using spectral analysis software.

Pre-emptor

Second type of equipment is a trolley mounted Vishleshak-I system which is capable of detecting explosives from variable distances of 2m upto 30 m. The system is based on time gated pre-resonant Raman detection technique.

This system has been tested for all kinds of explosives/ non-explosives in the form of liquids in bottles cuvettes and in the form of pills and particulates on slides for solid explosives.

Sensitivity of the system is 100 ppm from a distance of 5 m. The system is equipped with LabVIEW software for detection and identification of materials with visual and audio alarm.

Vishleshak-I

The third prototype is a tripod mounted system Vishleshak-II which is developed for detection range from 1 to 50 m using Pre-resonant Raman scattering. The system uses a pulsed UV laser for illumination of the target material. Collecting optics focuses the scattered light on CCD coupled spectrometer.

Spectral analysis software based on CWT is used for detection and identification of the threats.

Vishleshak-II

Laser Photo Acoustic Sensor Technique for Explosive Detection

Laser Photo Acoustic Sensor (LPAS) is a highly sensitive spectroscopic technique for stand-off detection of explosive material. Laser is focused on the distant sample and the scattered signal is made to fall on Quartz Crystal Tuning Fork (QCTF). An acoustic wave is produced on the sensor surface that drives the QCTF into resonance. Point and remote sensors using Quartz Enhanced Laser Photo Acoustic Sensor (QE-LPAS) for detection of chemical and atmospheric gases have been developed in the recent past.

Systems based on this technology are easy to use in field conditions in the presence of sunlight and attain detection range upto 100 m for traces.

LASTEC has developed QE-LPAS technique based explosive detection and identification system using tunable quantum cascade laser. Target sample is scanned for its absorption spectrum in the wavelength band of 7-12 μm and the receiving telescope collects and focuses the scattered signal on QCTF. Processing electronics amplify the resonant frequency signal and the analysis software computes the peak spectral position of target molecule for its reliable detection and identification.

The system has the capability of standoff trace detection of hazardous chemical and explosive material on adsorbed surface and liquid phase. Retro-reflector based QE-LPAS technique has also been demonstrated for detection of vapours/aerosol. Patent titled ***"Stand-off Detection of Chemical, Biological and Explosive Detection using Quantum Cascade Laser Photo Acoustic Spectroscopy"*** has also been filed.

Another variant of LPAS, i.e. Microphone based LPAS system is currently under development for stand-off trace detection of explosive material.

QE-LPAS System

Laser Countermeasure

Laser Spot Detectors

Laser Guided Weapons (LGWs) have been extensively used in the recent wars because of their high hit accuracy and minimal associated collateral damage. The LGW has an internal semi active guidance system that detects the laser energy and guides the weapon to the target illuminated by an external laser designator. Laser designator are illuminators used to tag the desired target. They are aimed so that laser energy precisely designates the chosen spot on the target. The reflected and scattered beam from the target is sensed by LGW seeker, which may be mounted on the same platform or on a different platform with respect to the laser designator.

Air Borne Laser Spot Detector

When the laser designator and the seeker are on same platform, pilot knows the exact coordinate and time of LGB release.

But, the situation becomes complex when the designator and LGB are on different platforms, because for laser guidance to be effective, LGB should essentially be in the desired laser envelope at the time of release. Hence for mission success, a suitable sensor called Air Borne Laser Spot Detector (LSD-AB) is installed on the LGB release aircraft that provides precise real time angular information with respect to the desired target. If the target lies within the field-of-view of LSD-AB, a fraction of scattered radiation will be collected by the opto-electronics front end of LSD-AB.

The sensor decodes and identifies the PRF code of the received radiation and matches it with the pre-programmed code in the seeker of LGB for that mission. Once the code is matched, sensor processes it to calculate location of the target. The information is then used by the pilot of the aircraft for delivering laser guided bomb.

LSD-AB has been developed and evaluated for various performance parameters.

Land Based Laser Spot Detector

If the optical axis of laser designator is mis-aligned with respect to the axis of ground based FLIR or Goniometer, laser will never fall on the intended target. Land Based Laser Spot Detector (LSD-LB) used on the target end will enable the user to accurately calculate the PRF and Angle-of-Arrival of the incoming laser. Corrective action can thus be taken for any mis-alignment in the axis of the designator and FLIR or Goniometer. Display of laser spot intensity profile provides information regarding beam quality of laser spot.

Laser Warning & Countermeasure System

Modern day warfare rely on extensive use of laser based electro-optic devices and systems as laser constitutes an indispensable component of any weapon platform. Such a situation emphasises the importance of timely detection of laser threats and initiation of a suitable countermeasure action. This necessitates that the friendly platforms are equipped with a suitable Laser Warning System (LWS) that would provide information about the incoming laser threat with high level of angular accuracy to track the laser threat and neutralise it by generating command to trigger suitable countermeasure system.

LASTEC has designed and developed a laser warning and countermeasure system for Armoured Fighting Vehicle (AFVs).

A LWS is capable of handling multiple type of laser threats and has an operational range of more than 6 km for laser designator type of laser threat. After detecting the laser threat along with its direction, it also has the capability to generate trigger signal to activate the grenade launcher for firing of smoke grenade in the direction of laser threat to obscure the platform under threat.

Technology of the LWS has been transferred to BEL, Pune.

Laser Threat Detection and Decoy System

The laser threat detection and decoy system is used for protection of the static military key points from attacks by laser guided bombs. The system comprises of laser warning system which detects the laser radiation from the enemy laser target designators, decoy laser and a dummy target which generates the same radiation as that of a laser target designator. LASTEC is developing Laser Threat Detection and Decoy System for protection of high value assets.

Important building blocks of Laser Threat Detection and Decoy System are Laser Warning System; Decoy Laser; and Dummy Target.

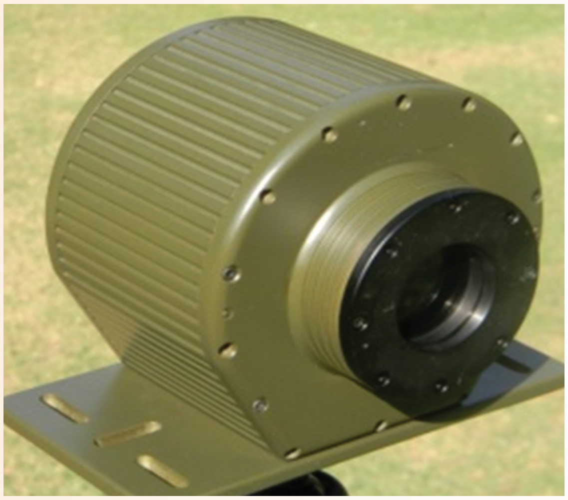
Laser Warning System

The function of the LWS is to detect the laser threat, determine Pulse Repletion Frequency (PRF) and generate an edge matching signal to give firing command to the decoy laser. It comprises of number

Laser Warning System

of laser warning sensors and a master controller. The laser warning sensors detects the laser radiation processes, determine the PRF and edge matching signals. It comprises of opto-electronic front end, signal processing and conditioning, embedded module for PRF decoding, and edge matching signal.

The master controller receive inputs from multiple laser warning sensors, processes the information and feeds the desired commands to the decoy laser. The master controller comprises of hardware and software module to interface with the laser sensor units and the decoy laser.



Laser Sensor

Master Controller

Decoy Laser

Decoy laser is a high energy laser source that takes command from laser warning system and generate a pulsed laser radiation synchronised with the PRF generated by the laser warning system. It is used to illuminate a dummy target to misguide the laser guided bomb on to the dummy target.

Decoy Laser

Dummy Target

Dummy target is a diffused surface which is illuminated by the decoy laser source with edge matched PRF signal. The scattered radiation is used to deceive the incoming laser guided weapon towards the dummy target.

Dummy Target

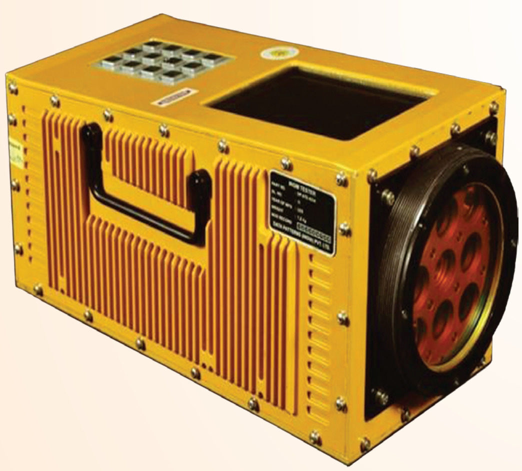
PGM Test System

IR Guided Missile Tester

IR Guided Missile Tester (IRGMT) is an equipment for performing functionality tests of R-73 IR guided missile onboard the Light Combat Aircraft (LCA). It is a calibrated IR source that generate the signatures of an aircraft as seen by the IR guided missiles.

It is an universal test system and can be used for testing other IR guided missiles as well. It is a battery operated test system with an embedded controller which is used to check serviceability of IR guided missiles.

The equipment consists of IR sources and optical filter assembly to perform the serviceability checks for single colour and double colour IR guided missiles by simulating signatures of jet exhaust, aircraft body and background noise. A 4x3 matrix keypad and 5.7" graphical colour LCD display are used for Man Machine Interface (MMI).



IR Guided Missile Tester

Griffin LGB Kit Tester

Laser Guided Bomb (LGB) tester is used for checking the performance of the Griffin LGB kit onboard the LCA. It simulates signatures of laser target designators for LGB delivery in terms of amplitude, wavelength and PRF code as seen by the seeker head of the LGB.

It is a battery operated test system with an embedded controller to check serviceability of LGB.

The system consists of laser sources; beam expander; and attenuation filter assembly to generate the stimulus signals (target signatures) required for validating LGB kit. A 4x3 matrix keypad and 5.7" graphical colour LCD display are used for MMI.

Laser Guided Bomb Tester

Laser Cross Section Measurement and Imaging

Stealth technology is considered to be modern and sophisticated technology which aims in minimising transmitted and reflected energies like heat, light, sound, electric potential, etc. to deny the opponent to locate, track, identify and attack its target.

The high precision weapons with semi active laser seekers came in wide use and present an increasingly serious threat. Therefore the efforts to protect the armoury, i.e., ship from high precision weapons are mainly focused on development of methods and tools for measuring and reducing their laser signature.

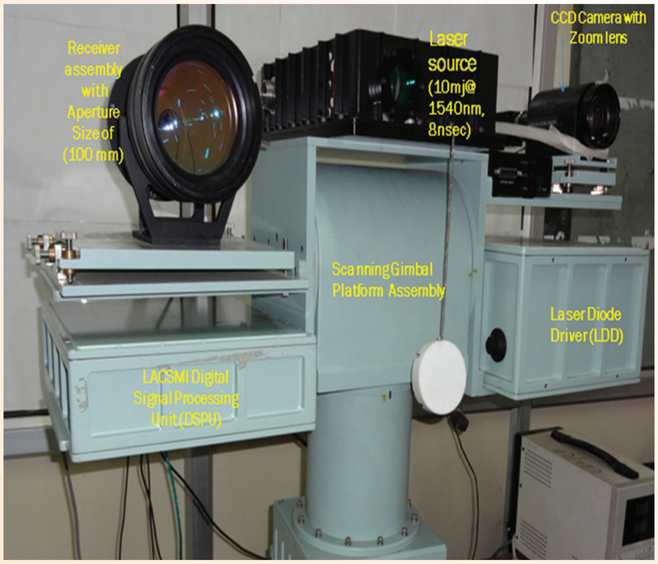
So far, cross section measurement of targets in all domains of armed forces was restricted to 'radar cross section' only. But with the advent of laser based weapons, 'Laser Cross Section' measurements have became equally significant. This is an unique application of lasers in stealth technology and its countermeasures.

LASTEC has developed Laser Cross Section Measurement and Imaging (LACSMI) system under Engineering Application of Stealth Technology (EAST) Project of NSTL, Visakhapatnam. This is a complex and critical system, which has been attempted for the first time in country and is an amalgamation of multidisciplinary fields.

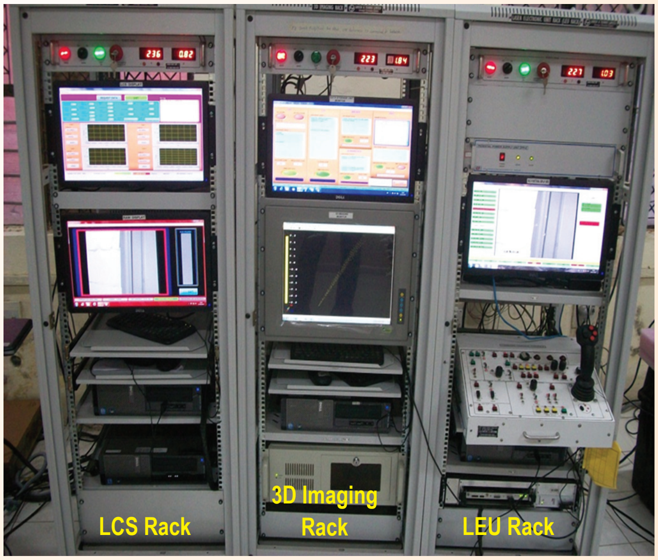
The system was used for 3D Imaging of naval targets in collaboration with IIT-Kanpur. A joint Indian Patent (LASTEC and IIT-Kanpur) on ***"A method and system for generating 3D geometry of moving object using Laser Scanning"*** has also been filed.

The system comprises of following major subsystems:

- Eye safe 1540 nm based 20 Hz,10 mJ laser source
- Laser receiver of 100 cm aperture with InGaAs integrated detector
- High-end laser signal processing unit
- Two-axis precision scanning gimbal system
- Automatic video target tracking system
- LACSMI electronic unit with MPC 860T power PC based master system controller with real time embedded software
- Laser cross section measurement unit for implementing LCS Algorithm
- 3D imaging unit with 3D visualisation software
- Data storage unit for logging all the experimental data
- Motion measurement unit along with GPS ,VHF trans-receiver and beacon receiver
- Motion compensation algorithm
- Calibrator hardware with 10 per cent reflectivity with dimension 10 inch X 10 inch; 99 per cent reflectivity with dimension 2 inch X 2 inch; and 5 per cent reflectivity with dimension 1 m X 1 m



Axis Pedestal with Payloads



LACSMI Electronic System consisting of LCS and 3D Imaging Unit

Laser Materials

LASTEC is currently focused on developing processes for producing optically transparent laser ceramics (Nd-doped YAG and Yttria) and solid state grown single crystals (Nd-doped YAG) by using Czochralski crystal growth technique. Neodymium doped Yttrium Aluminum Garnet (Nd:YAG) has proven to be one of the best solid state laser material in the history of quantum electronics. Czochralski crystal growth of Nd:YAG is a matured, highly reproducible and relatively easy technological procedure.

One of the few drawbacks of Nd:YAG single crystal growth is its relatively low growth rate, ~1 mm/h, making the production of large laser rods and slabs impossible, which are needed for high power and high energy laser applications. The sesquioxides (Sc_2O_3,Y_2O_3 and Lu_2O_3) can easily be doped with high concentration of rare earth ions and exhibit a higher heat conductivity than YAG. These properties make the sesquioxides attractive for high power solid state lasers.

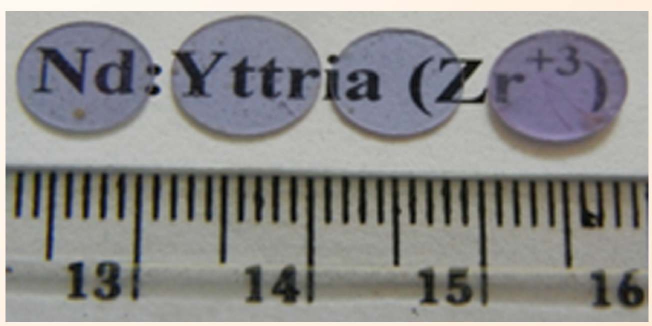
However, growth of large crystals from the melt is a difficult task due to the high melting point (more than 2400°C) and its phase transition occurs before melting point. Since fabrication of ceramic takes place at much lower temperature than melting point, it offers a better alternative to fabricate sesquioxide ceramics as the futuristic laser material. This has led to some research on transparent ceramics to satisfy the requirements of larger and more powerful solid state lasers.

LASTEC is developing transparent laser quality ceramics using nano powder synthesis and modern ceramic technology. Nanocrystalline powders are synthesised by using wet chemical approaches such as microwave assisted gel combustion and coprecipitation routes. These nanoparticles are characterised, compacted and densified to the fully transparent ceramic laser materials through the vacuum sintering and hot isostatic pressing.

LASTEC has achieved about 80 per cent transmission at 1064 nm with 1- 4 per cent of Nd doping for Nd: YAG and Nd: Yttria ceramic.

LASTEC is working on the growth of laser crystals using melt growth technique and is equipped with computer controlled Czochralski Crystal Puller. LASTEC has successfully grown the most popular Nd:YAG and Nd:GGG laser crystals having diameter 25- 40 mm and crystal cylinder length upto 70 mm, typical crystal length for obtaining laser rod up to 50 mm length to be used in laser range finder and laser target designator. The crystals have been tested for laser applications and produced the output comparable with the commercially available samples.

Nd:YAG Polycrystalline Ceramic



Nd:Yttria Polycrystalline Ceramic

Nd:GGG Single Crystal

Nd:YAG Single Crystal

Infrastructure Facilities at LASTEC

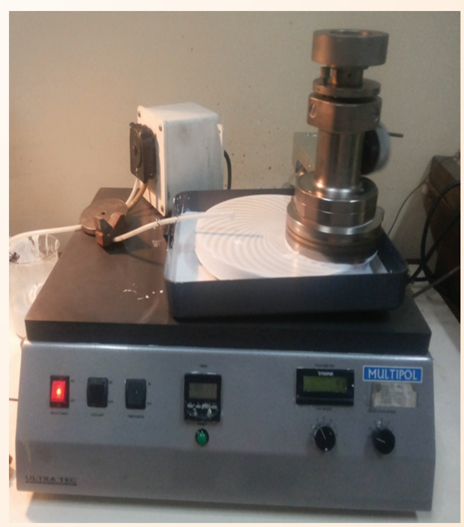
LASTEC has established infrastructure facilities for material processing, testing of materials, optics, optical components and for test and evaluation of electro-optic systems.

Material Processing Facilities

High Temperature Vacuum Furnace

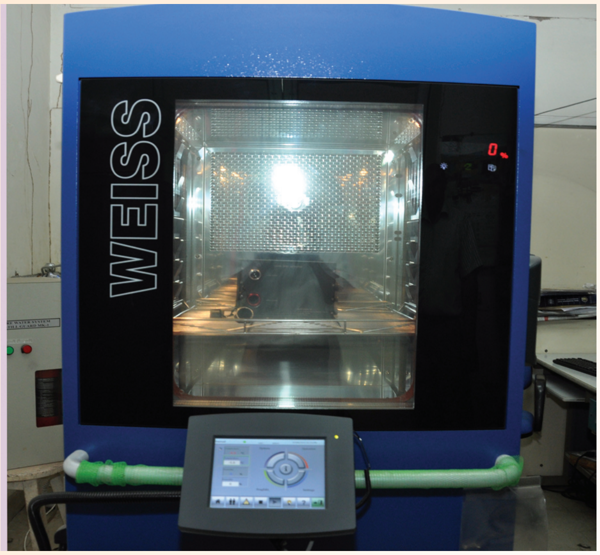
Czochralski Crystal Puller

Cold Isotatic Press



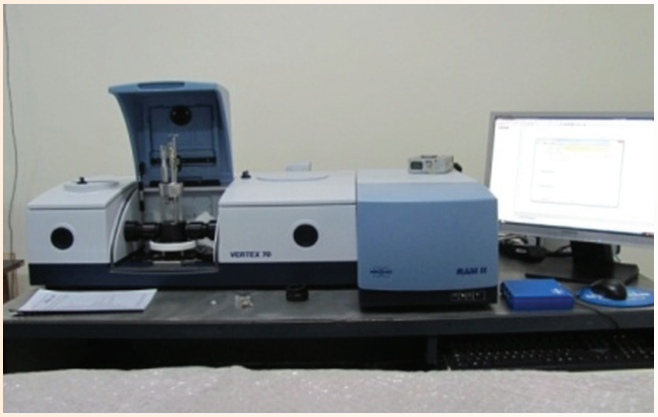
Lapping Polishing Machine

Materials/Optics/Optical Components Test Facilities

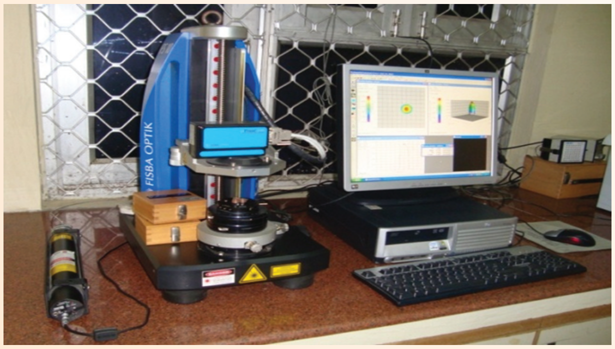


Environmental Test Chamber

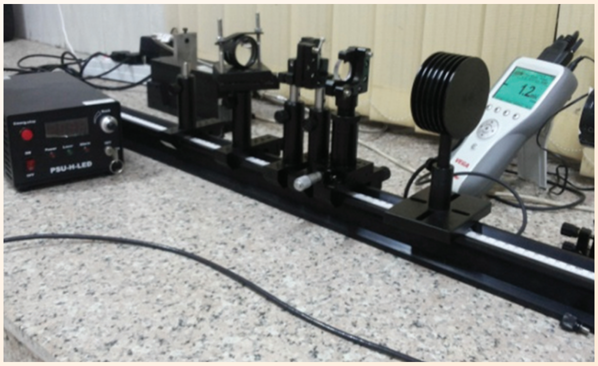

Phase Shift Inferometer


High Resolution FTIR cum FT Raman Spectrometer


Vision 3D Measurement System



Twyman-Green Interferometer


Lasing Test Set-up

Technology Focus
टैक्नोलॉजी फोकस

Facility for Electro-optic System Testing (FACET), Chandigarh

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Technology Focus focuses on the technological developments in the organisation covering the products, processes and technologies.

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