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Electro-Optical Products and Technologies

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

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From the Desk of Guest Editor

Instruments Research and Development Establishment (IRDE), Dehradun, under the umbrella of DRDO, is devoted to design, development and technology transfer of optical and electro-optical instrumentation primarily for the defence services and paramilitary forces. Areas in which IRDE has established the technology solutions include design and development of fire control system comprising night vision devices, laser-based instruments, stabilised payloads, proximity sensors and seekers.

IRDE's core competence is design and development of optical, electro-optical and optronic instruments for surveillance, reconnaissance, piloting, navigation, guidance, target identification and acquisition, designation, ranging and countermeasures under all weather conditions during day and night. Fire control systems and devices, infra-red search and track systems, stand-alone surveillance systems, optical design, holography, optical image processing and photonic target recognition techniques, adaptive optics, integrated optics, micro-optics and nano-photonics, terahertz sources and imaging, and control systems design for stabilised payload are other areas of work at IRDE.

Products developed by IRDE in the recent past include electro-optical fire control system for navy, integrated multi-function sight and gap measuring device for army, indigenisation of TI sights for AFVs and lightweight portable laser target designator.

IRDE, in association with sister laboratories like ARDE, DRDL and RCI are developing various equipment to meet the User requirements.

This issue of Technology Focus highlights IRDE's recent contributions towards development of various electro-optical systems for the different platforms and enabling technologies.

Benjamin Lionel

Outstanding Scientist & Director
IRDE

Electro-optical Products and Technologies

Instruments Research and Development Establishment (IRDE), Dehradun is devoted to research, design, development and technology transfer in optical and electro-optical instrumentation primarily for the defense services. The origin of IRDE dates back to the establishment of Inspectorate of Scientific Stores in 1939 at Rawalpindi (now in Pakistan). After independence it took the shape of Technical Development Establishment covering both R&D and inspection functions in the fields of instruments and electronics and was located at Dehradun. The establishment, during subsequent years, shed some of its R&D and AHSP responsibilities and came into existence, in its present form as IRDE on 18 February 1960.

IRDE has in-house capability for the design, fabrication, assembly and testing of optical systems for visible as well as the infrared region of spectrum. IRDE's core competence lies in the development of electro-optical systems, such as low light level TV, day vision, image intensifier tube and thermal imaging based night vision, laser-based instrumentation, LOS stabilization and photonics research. IRDE develops instruments for handheld and platform mounted applications including land-based, naval and airborne platforms.

Border Surveillance System

Electronic Surveillance with Remote Operation Capability for High Altitude Border Areas

Border Surveillance System (BOSS) has been developed to carry out all weather surveillance and to monitor the high altitude border areas. It consists of Battle Field Surveillance Radar (BFSR-XR), Electro-optical (EO) sensors comprising of day camera, thermal camera, eye-safe LRF along with geo-location sensors (DMC& GPS) kept at observation post. It is also equipped with hybrid energy source. It transmits the real-time video and data to control station through wireless and fiber optic link. The device has advanced image processing features such as image enhancement, motion detection, panoramic view and computation of target co-ordinates.

It eases the hardship faced by military personnel deployed in harsh condition, for physical surveillance. It provides electronic surveillance solution for high altitude border areas exposed to sub-zero temperature, remotely.

The product is under induction into Indian Army.

Salient Features

- ◊ Provide all weather 24 x 7 electronic surveillance
- ◊ Networkable
- ◊ Equipped with advanced image processing feature for hassle free surveillance
- ◊ Powered through hybrid power source
- ◊ Unmanned installation with remote operation capability
- ◊ Data and video transmission capability
- ◊ Integrated De-icing and De-fogging module and security camera

Product Impact

- ◊ Self-reliance in developing cost-effective surveillance equipment
- ◊ Successful development of BOSS has led to self-reliance in the field of indigenous surveillance equipment for manned/unmanned posts
- ◊ Indigenous production of the equipment will result in considerable savings in remote surveillance. Technology may be used for homeland security and in border areas affected by conflicts. These systems have the potential to be exported to countries having similar requirements

Multi-Spectral Surveillance System

A Multi-Spectral Surveillance System (MSS) has been developed, featuring a broadband detector and broadband optics. It has a laser range finder, common sensor interface and image processing electronics. MSS was designed as a battery operated, light-weight tripod mounted system providing day and night surveillance capabilities. The complimentary information of multiple bands at different ranges enables acquisition of potential threats in adverse weather conditions. It is an effective measure to detect camouflaged targets of interest.

Salient Features

- ◊ Broadband surveillance
- ◊ Day and night capabilities
- ◊ Better imaging through smoke and haze

3-Mega Pixel Infrared Detector-based Long Range Surveillance System

A 3-Mega Pixel Infrared Detector-based Long Range Surveillance System (MILRS) has been developed to provide long-range day and night surveillance capability. MILRS comprises of a high resolution cooled Thermal Imager (TI) and full HD colour day camera.

Due to large format and small pixel size, the system provides wider field-of-view coverage along with longer recognition ranges. Large format also offers user the critical situational awareness through wide FOV coverage. Another benefit gained by larger format is to provide enhanced digital zoom capability without image degradation.

Salient Features

- ◊ Wider FOV coverage with very high spatial resolution
- ◊ Improved situation awareness
- ◊ Longer ranges
- ◊ Digital zoom with greater detail without image degradation

Simulated Test and Interrogator Kit for AFVs

Simulated Test and Interrogator Kit (STIK) for AFVs will be used to evaluate the performance of various units of Guided Weapon System (GWS) of AFVs in the field condition before firing the missile. GWS is responsible for providing Laser Beam Rider (LBR) guidance to the missile. The LBR system is a semi-automatic controlled system employing tail-orienting of the missile on a laser beam. In a LBR guidance system, the guidance system projects an information encoded laser beam of sufficient power in the direction of the target. The missile is fired into this beam and thereafter gets guided in the beam till it hits the target. The system includes a laser transmitter for generating and projecting a laser information field towards the target and an optical sight for aiming the laser beam.

A GWS comprises of three units namely the main sight, Automatic Control Unit (ACU) and voltage converter. The role of the main sight is generation of coded laser beam of desired specifications and ACU provide all the control signals to sub-unit and also interacts with fire control system of tank. The role of voltage converter is to provide voltage and current required for generation of laser.

STIK is a compact and ruggedized system, which will capture, in real time, the laser information field and time parameters during the total time of flight of the missile. STIK system is used to test all three units of GWS.

STIK comprises of 06 sub-units as shown in figures. The system will be integrated electrically and mechanically without any modification of the tank. The STIK will be operated by self-sustained power source. It first checks the GWS in combined mode where optical unit, interrogator unit, light source and rechargeable battery are used. In this mode relevant tests are carried out and based on these tests the failure of sub-units can be identified. Testing of ACU and voltage converter is carried out by ACU Test Unit and voltage converter test unit, respectively.

The STIK also stores qualitative data corresponding to each test for further analysis. It also provides data storage feature with time stamping and data protection. Initial alignment of optical unit with the main sight is very important to start the test. A CCD camera used in optical unit makes this alignment very easy. STIK also provides the divergence and centroid trajectory of laser beam during the time of missile fire, which helps to understand and diagnose the system more deeply.

Optical Unit

Interrogator Unit

Light Source

ACU Test Unit

Voltage Converter Test Unit

Re-chargeable Battery Power Source

Athermal Laser Target Designator

Laser target designators are true force multipliers in modern-day warfare as they enable precision strikes against military targets using laser guided bombs, artillery shells and missiles. The diode pumped Athermal Laser Target Designator (ALTD) is an state-of-the-art military laser equipment that has several distinct advantages over the earlier designators.

Firstly, the athermal design of this designator allows it to operate efficiently over a wide range of ambient temperatures unlike earlier designators that required precise temperature control of the laser diodes using thermo-electric cooler modules for maintaining their performance. This feature of the ALTD has improved the efficiency and reduced the power consumption by almost 40 per cent, thus reducing the size and weight of the battery required. As no active temperature control is required for ALTD, it has negligible start-up time, thereby saving precious time in the battlefield. In comparison, the earlier designators required up to two minutes to be ready for use.

The advanced single channel optics combines the functions of day sight and laser trans-receiver with a common aperture, resulting in a compact, rugged and lightweight design. The designator produces laser pulses with a nominal repetition rate of 20 Hz.

Salient Features

- ◊ Compact and light-weight
- ◊ Built-in Range Finder
- ◊ Low power consumption
- ◊ Instant start capability
- ◊ Built-in DMC and GPS
- ◊ Operation with rechargeable Li-ion batteries
- ◊ Picatinny rail for mounting SWIR camera or Thermal Imager

Product Impact

Self-Reliance in Development of ALTD

Design and development of ALTD has led to self-reliance in the field of indigenous development of Laser Target Designators. The ALTD enables ranging and terminal guidance.

Indigenous production of the equipment will result in considerable savings in foreign exchange and help replace unserviceable imported equipments. These systems have the potential to be exported to countries having similar requirements.

Commander's Sighting Systems for AFVs

Based on the requirements projected by Indian Army, IRDE had undertaken a mission mode project for the design and development of Commander's Sighting Systems (CSS) of AFVs.

Commander's Thermal Imagers (CTI) is used for battlefield surveillance and acquisition of targets both during day and night. They also enable the hunter killer capability of AFVs during night. The existing IC tube-based night sight is replaced by thermal imager and it has been integrated with existing housing of commander's sights of AFVs in form fit condition while retaining existing day sight. The thermal imager is based on MWIR (3-5 µm) enhancing the recognition range. With these upgraded commander's sights, the tank commander will be able to carry out independent surveillance and target acquisition during day/ night thereby removing the existing night blindness. An eye safe Laser Range Finder (LRF) has been incorporated to get accurate ranges of the target in commander's sighting system. A firing graticule in thermal imagers has been implemented which automatically corrects by calculating the ballistic offset for selected ammunition to enable faster reaction time.

Salient Features

- ◊ Form-fit configuration
- ◊ Functional replacement of night sight with enhanced recognition ranges
- ◊ Retention of existing day sight
- ◊ Retention of Hunter Killer capability
- ◊ Continuous zoom along with fixed discrete field of view
- ◊ Day and night operation
- ◊ Image processing features
- ◊ Integral eye safe laser range finder in Cdr TI

Product Impact

After installation of these sighting systems the in-service AFVs will have an enhanced night fighting capability.

Production of the commander's sighting systems will be done at Bharat Electronics Limited (BEL), Machilipatnam and Opto Electronics Factory (OLF) Dehradun. The system is cost-effective and has potential to be exported to countries having similar AFVs in their armed forces.

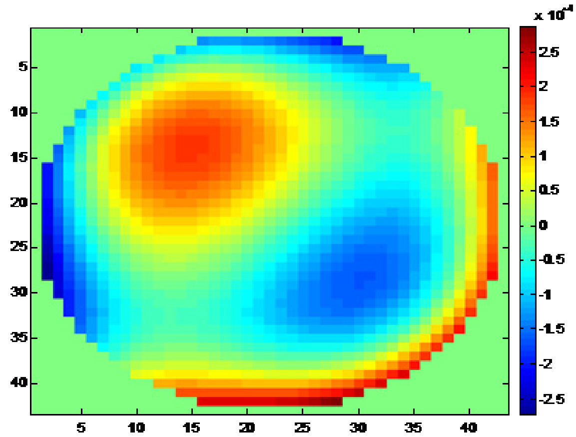
Fast and High Resolution Shack-Hartmann Wavefront Sensor

Shack-Hartmann Wavefront Sensor (SH-WS) is being used in various applications in the last several years. One of powerful uses of SH-WS is in adaptive optics (AO), in which high speed sensing is required to measure the turbulence induced wavefront errors. In addition this sensor has commercial applications like ophthalmology, optical testing, laser beam analysis, semiconductor manufacturing industry, etc.

As an alternative to interferometry, the SH-WS is simple, compact, robust, and relatively vibration insensitive. A SH-WS consists of lenslet array, CMOS sensor, and fast acquisition with customized software. Suitable fast SH-WS is not commercially available for AO applications. Therefore the laboratory in-house developed a high speed > 1000 fps with 16 x 16 sub-apertures SH-WS for AO application and further upgraded it to high resolution with 42 x 42 sub-apertures SH-WS as shown in the figures. Measurement of coma dominated wavefront aberration of a 4X day sight is shown as test results in figures.

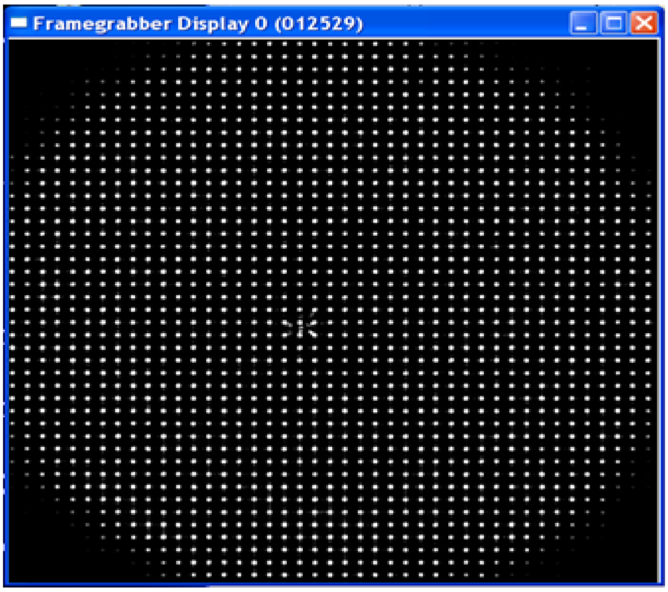
Salient Features

- ◊ Precision lenslet mounting assembly
- ◊ Sub-aperture selection and S/w driven alignment procedures
- ◊ Customized VC++ based in house developed software
- ◊ MATLAB-based engine for offline aberration analysis
- ◊ High speed to measure atmospheric turbulence induced aberrations
- ◊ High resolution to measure Zernike polynomial aberrations over entrance pupil



Coma dominated aberrations: Test result

High speed SH-WS prototype



High resolution Hartmann spots

Image Fusion Techniques for Electro-optical Systems

Image fusion is a subset of the more general field of data fusion. Image fusion combines multiple images of the same scene with complimentary or redundant information to generate a new composite image with better quality and more features. It can provide a better interpretation of the scene than each of the single sensor images can do. The objective is to reduce uncertainty and minimize redundant information in the multi-sensor output while maximizing information present in a scene. It has received significant attention in defense systems, medical imaging, robotics and industry, etc.

Image fusion system requires number of processes to convert two or more input images into a fused image. Images from the individual sensors are pre-processed (image enhancement) and aligned with one of the reference frames. The FOV compensation and spatial alignment is performed through image registration process. Finally these images are fused, as per the fusion methods and fusion rules to generate the fused imagery. Figure shows the generic processing requirement for the generation of fused imagery to create the single output image from multiple image frames of individual sensors.

There are multiples steps required for image fusion which are as follows.

- ◊ Mechanical alignment of imaging sensors: Sensors installed on a platform or as a part of surveillance suite, are to be aligned so that their optical axes are made parallel to each other
- ◊ Image registration: This step is required to compensate different resolution, sensors' FOV so that corresponding pixels of two/ more sensors are overlapped at same position. It is achieved by electronic processing method.
- ◊ Image fusion: Once, registration is completed successfully, pixel level fusion algorithms are applied to make composite image from multiple imaging sources to enhance the information.

Image Fusion

Various Image fusion algorithms, i.e., weighted average, HPF, Wavelet-based and Laplacian Pyramid-based image fusion have been designed, simulated and their performance and computation requirements have been analyzed. FPGA and DSP-based image fusion hardware have been developed.

Image synchronization, Affine Transform and bilinear interpolation-based image registration algorithm, weighted average, HPF and Laplacian Pyramid (LAP) based image fusion algorithms have been implemented in hardware. Image Registration and fusion of video from EO Sensors has been implemented in real time. Figure Shows the image fusion-based surveillance system developed at the laboratory.

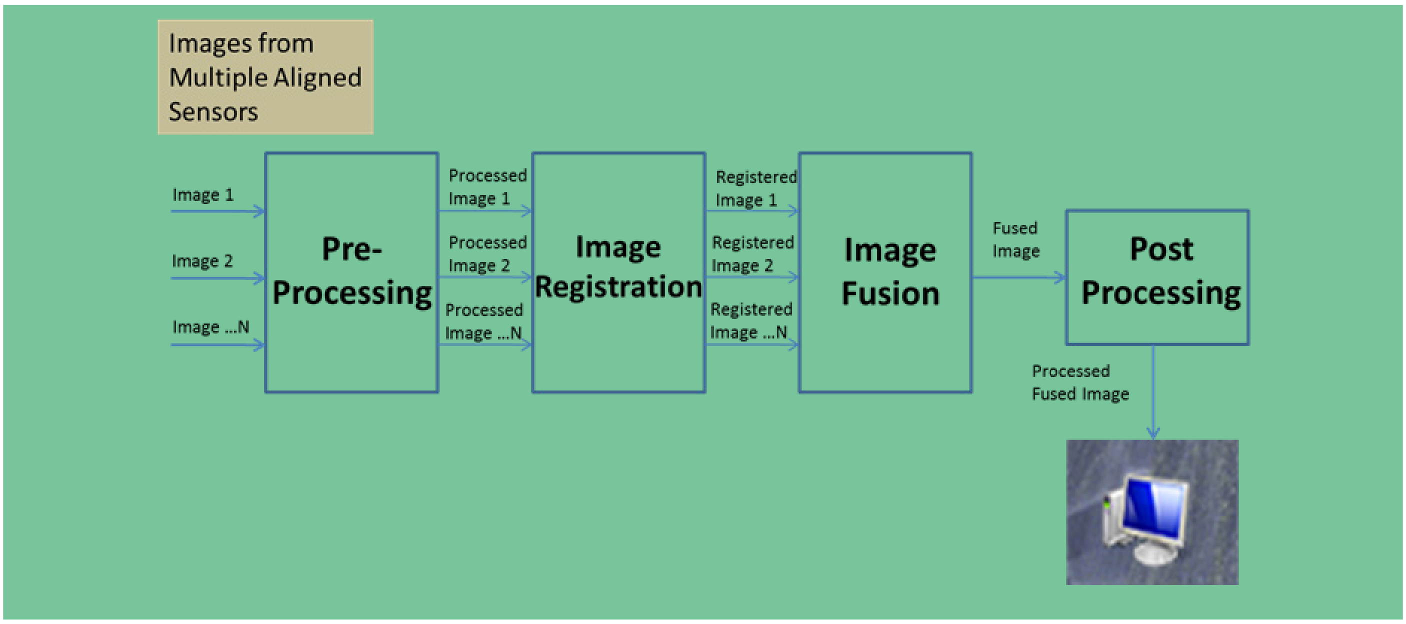


Image Processing Framework for Fused Imagery

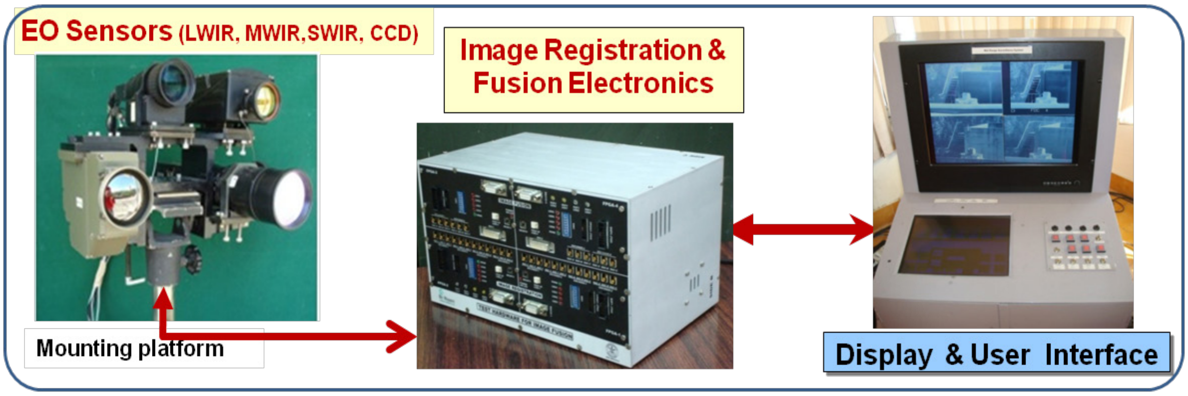


Image fusion-based Surveillance System

Image Results

Figure shows the image acquired from CCD Camera, thermal imager and fused image. The first image is colour CCD image showing smoke due to fire and a person walking behind smoke is captured by LWIR camera. The Fused image captures information from both the sensors. Fused image clearly conveys that there is fire as well as a person present in the scene. Multi-sensor image fusion has received significant attention in defense systems, geosciences, medical imaging, remote sensing, robotics, industrial engineering, etc. In defence, target detection, tracking and classification system identification, concealed weapon detection, battlefield monitoring, night pilot guidance, improved situational assessment/ awareness, improved robustness, can utilize fused imagery for better situational awareness. Recently, Indian Railway has shown interest to install this system in front of train engine so that traffic signal and any animal/person/vehicle/object on track can be seen and output is shown in single composite image. It will reduce the accidents due to poor visibility and in night conditions. The developed techniques are being used in systems like Drivers Night Sight (DNS) for AFV, etc. being developed at the laboratory.

There could be following applications in near future.

- ◊ Surveillance suite in which multiple monitor cannot be accommodated
- ◊ Transmission of multi-sensor suite information to command headquarter, which can be clubbed in single image/ video stream
- ◊ Single video can be archived instead of multiple videos to save storage
- ◊ It can reduce operator's fatigue to monitor multiple displays

CCD Image LWIR Image

MWIR Image Fused Image

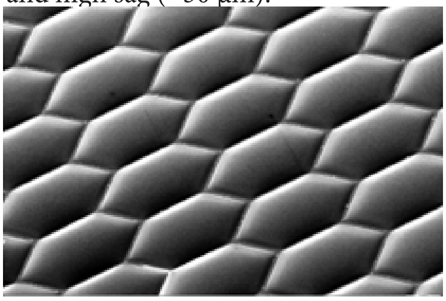
Results of image fusion

Micro-optics and Nanophotonics Technologies

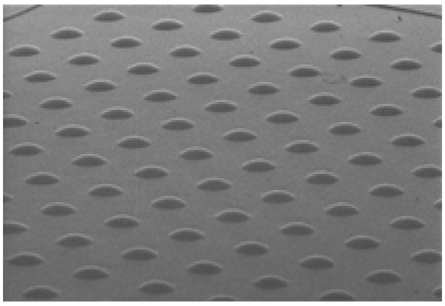
The last few decades have seen the optics industry adopting some of the fabrication techniques used in semiconductor industry. This has paved the way for two major trends in optics industry – miniaturization and large volume production. Miniaturization has resulted reduction in system volume thereby reducing system weight. Cost-effective techniques for large volume production has resulted in low cost devices. Micro-optical components are increasingly finding many diverse applications. In the field of nano-photonics the motivation is to control the optical properties of materials. Nano-photonics is defined as the science and engineering of light and matter interactions that take place on wavelength and sub-wavelength scales where the physical, chemical or structural nature of natural or artificial nano-structured matter controls the interactions. An enormous range of technological developments would become possible if we could engineer materials that can provide us complete control over light propagation over the desired range of frequencies. Keeping in view the futuristic applications offered by these emerging technologies, DRDO has taken an initiative in collaboration with leading R&D institutions of India. The main technologies developed in Micro-optics and Nano-photonics areas are:

Micro-optics

IRDE has developed Micro-optical components such as microlens arrays and computer generated holograms for various applications including wavefront sensors, imaging, null testing of aspheric optics and pattern projection. Microlens arrays with diameters ranging from 200 µm to 1 mm, sag varying from 3 µm to 60 µm with circular, square or hexagonal apertures have been realized at IRDE. Arrays with 30x30 and fill factor upto 95 per cent have been realized and their use in wavefront sensing has been demonstrated. Figure shows the scanning electron microscope (SEM) image of a microlens array with hexagonal aperture and SEM image of microlens array with circular aperture and high sag (~50 µm).

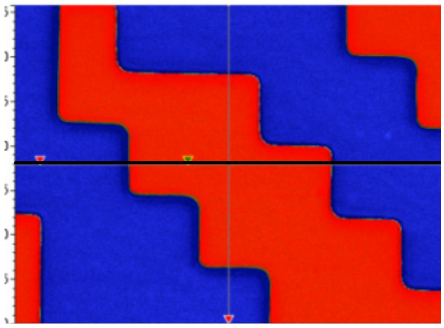


SEM image of microlens array with high fill factor and hexagonal aperture

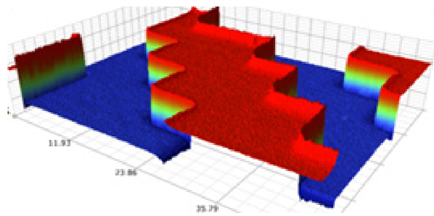


SEM image of microlens array with high sag and circular aperture

Computer Generated Holograms (CGHs) are Diffractive Optical Elements (DOEs) that can manipulate the incident light almost arbitrarily. Expertise is available at laboratory in design, fabrication and characterization of a binary phase as well as amplitude CGH for various applications. The designed binary CGH is fabricated by lithography and etching process. It is possible to replicate these micro-structures to a stable polymer by soft lithography technique. For characterization, 3-D non-contactoptical profiler and scanning electron microscope have been extensively used. Figure shows the profile of a CGH using optical profiler. CGHs with feature sizes as small as 5 microns and pattern size as large as 40 mm x40 mm have been achieved and the technology has been established at IRDE for pattern projection and testing of aspheric optics using CGH as null element.



Profile of a CGH using non-contact profiler



3-D image of profile as taken by non-contact profiler

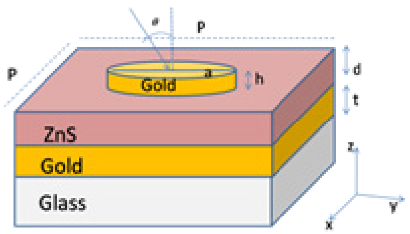
Nanophotonics

IRDE has been actively working on metamaterials, photonic crystals in collaboration with IIT Kanpur, IIT Delhi and IISc Bangalore and on Silicon Photonics in collaboration with IIT Madras.

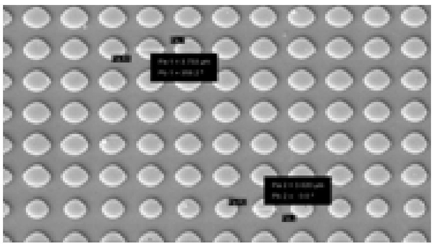
Metamaterials

Metamaterials are artificially engineered nanostructures of dimensions much less than the wavelength of light. Metamaterials have immense defence applications such as electromagnetic invisibility, broadband high efficiency absorbers, frequency selective absorbers, etc.

Expertise has been developed for design, simulation, fabrication, and characterization of highly absorbing metamaterials at various frequencies ranging from visible to NIR to LWIR to Radar frequencies. A typical unit cell design of metamaterial absorber and SEM micrograph of fabricated metamaterial for a LWIR frequency is shown in figures.



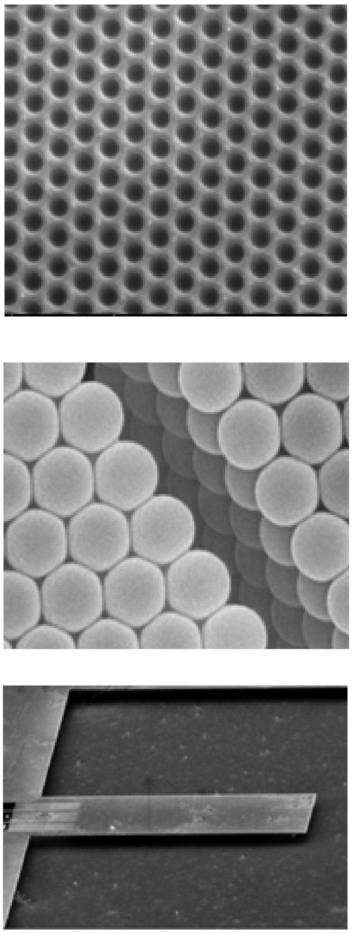
A typical unit cell design of a Metamaterial absorber consisting of metal-dielectric-metal trilayer with patterned top metal layer



SEM image of a fabricated absorbing metamaterial for LWIR frequencies

Photonic Crystals

The research in Photonic crystals opens new possibilities for an "optical chip" – leading to strong hopes for large-scale integration of optoelectronic components. In collaboration with IIT Kanpur and IISc Bangalore, IRDE has developed expertise in design and fabrication of Photonic crystals. Figure shows a photonic structures made on Silicon wafer with precisely controllable hole size. Apart from this self-assembled Photonic Crystals (3-D PhC) have been fabricated from colloids by horizontal self-assembly and characterized for their Photonic stop band characteristics. A typical 3-D Photonic crystal structure is shown in figure.



(a)

(b)

(c)

(a) A typical 2-D Photonic crystals structure in Silicon made by Focussed Ion Beam milling; approximate hole diameter is 365 nm and hole separation is 600 nm. (b) 3-D Photonic crystal structure made by colloidal self-assembly method; approximate colloid size is 235 nm. (c) SEM picture of Photonic crystal ring resonator fabricated on Silicon cantilever.

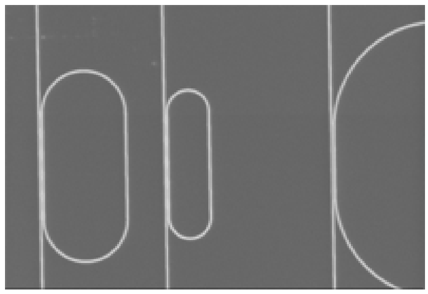
A miniaturized photonic band-gap resonator-based device has been realized for sensing the mechanical force. The technology of design and fabrication of photonic crystal ring resonator on a Silicon cantilever has been established.

The minute change in resonant wavelength shift during deformation of cantilever due to external force is sensed in this device.

Silicon Photonics

Silicon Photonics is an ideal platform for optics and electronics integration and it is supposed to play a key role in realizing data communication at lightning speed. In collaboration with IIT Madras, technologies have been developed for design and fabrication of various Silicon Photonics components. Single mode Photonic wire waveguide in SOI substrate with low loss has been demonstrated.

A micro-ring resonator using these waveguides has been realized as shown in figure.



SEM image of a micro-ring resonator using photonic wire waveguides, fabricated by e-beam lithography

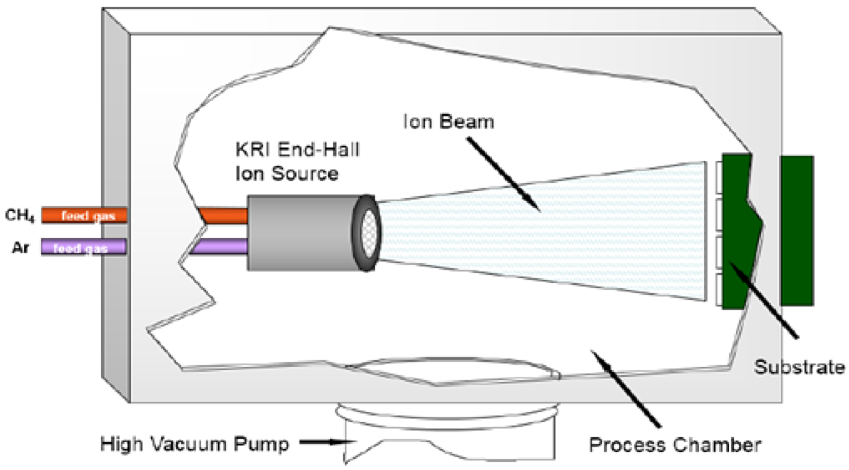
Diamond-like Carbon Coating Plant

Germanium is the most commonly used window and lens material in Mid-Wave Infrared region (MWIR) imager. It is easily scratched by sand and readily affected chemically by salt water. Germanium components have good optical performance but their mechanical and chemical durability is very poor. Also the critical requirement is that the material should be transparent in the MWIR region.

The hard forms of amorphous carbon and hydrogenated amorphous carbon are known as Diamond Like Carbon (DLC). It has some extreme properties similar to diamond but it can only be deposited in the form of anisotropic disordered thin film. DLC films have received considerable attention due to its high chemical stability, optical transparency in MWIR region and extreme hardness. DLC is being used as a coating of germanium optics to protect the components against corrosion and rain impact damage. With the requirement to protect the external surface of germanium component and unique properties of DLC, the DLC coating facility is created. Also the DLC films are widely used on number of cutting tools due to its high mechanical hardness.

Direct ion beam deposition is a state-of-the-art deposition technique, for optical application of DLC. It provides a number of advantages over other techniques as this has the advantage of being able to deposit high quality coatings at very low temperatures (near room temperature). Direct ion beam DLC deposition provide low absorption film, repeatable optical properties, low stress film and high deposition rate. So, direct ion beam deposition technique is selected for fabrication of DLC over germanium substrate at IRDE. With the help of vacuum pump, deposition chamber is evacuated to 5×10^{-5} mbar. Then hydrocarbon gas is introduced though ion gun. This ion gun dissociate hydrocarbon into carbon and hydrogen and accelerate carbon towards substrate. So, substrate is bombarded with a controlled energy of carbon atoms and this induced the formation of DLC film on the substrate. By varying various parameters; rate of deposition, index of film, thickness of deposition and other properties can be tuned. Scheme of ion beam DLC deposition is shown in figure.

DLC coating plant as shown in figure; Thickness and refractive index of the deposited film is tuned in such a way that it provides anti-reflection property over germanium substrate and enhance the transmission. After DLC coating, peak transmission enhanced from 46 per cent to 98 per cent at 2 mm thick germanium substrate. This durable anti-reflection coating is designed to withstand the most severe environmental conditions likely to be encountered in the military or industrial operational applications. The coating will show no evidence of deterioration when subjected to the salt spray fog test per MIL-C-675, severe abrasion and adhesion test per MIL-C-48497, and the windscreen wiper test in the sequence listed. The plant is installed, commissioned and operational.



Scheme of direct ion beam DLC deposition

Single Point Diamond Turning (SPDT) Machine

Generally, optical instruments have glass optics with number of lenses having spherical surfaces. These are used during day and night with external illumination and image intensifier tube-based technology. With the advent of thermal imager, based on infrared technology, there is a huge improvement in night vision instruments. The instruments based on this technology use special optical transmitting materials like Germanium, Silicon, ZnS, ZnSe, etc.

The non-conventional design of optical system uses optical elements with aspheric surfaces and asphero-Diffractive Optical Elements (DOEs) which reduces the number of optical components and makes the system very compact. Hence to fabricate the aspheric surfaces and asphero-diffractive optical elements (DOEs) at IRDE, a state-of-the-art Single Point Diamond Turning (SPDT) machine was installed and commissioned in July 2016.

The SPDT machine, Nanoform 250 Ultra is a high precision Computer Numerically Controlled (CNC) machine for the generation of spherical, aspheric and asphero-DOE and other complex surfaces of very high order of form accuracies and surface finish.

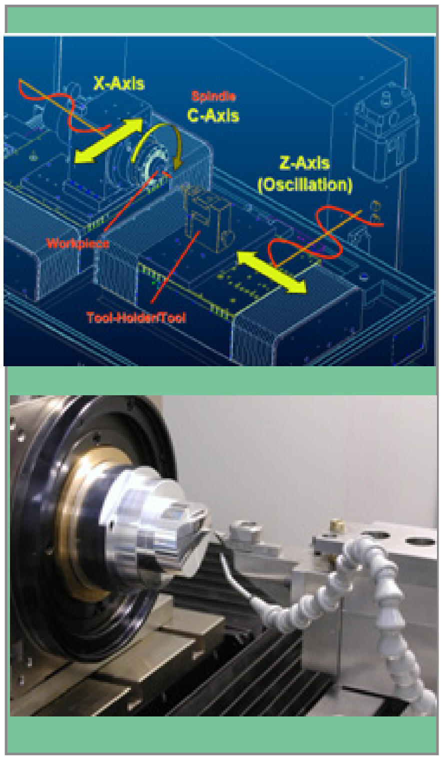
To achieve the desired accuracies, machine is designed with special features as hydrostatic slide ways, spindle, based on air bearing and pneumatic vibration isolation. The machine is equipped with Rotational B axis, Slow Tool Servo (STS) and Fast Tool Servo (FTS) for generation of free form surfaces, DOEs and micro-lens arrays.

Machine also has *in situ* online metrology systems for the verification of the parts.

Nanoform 250 Ultra Machine

High Performance SP150 Spindle with Integrated C Axis and Slow Tool Servo

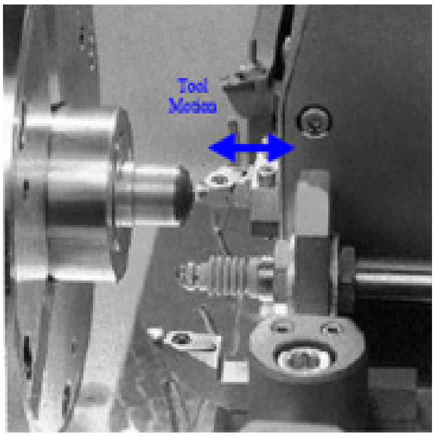
STS is used for rapid manufacture of freeform elements with low spatial density (i.e., a small function of FF elements on the surface). For freeform elements with high spatial density, users typically order an FTS unit. STS relies on the machine tool slides to actuate the tool holder synchronous with the rotation of the C axis spindle. Tool position for STS is pre-calculated and commanded as three coordinated axes of motion on the machine controller.



Slow Tool Servo

Fast Tool Servo

- ◊ Manufacture of small departure freeform components, i.e., Lens-let arrays
- ◊ Short stroke actuator holds a diamond tool and mounts onto the Z-slide of a lathe. The actuator is driven by closed loop position feedback
- ◊ With the use of a dedicated controller, the tool position is calculated and commanded in sequence with the rotational position of the work spindle and slide



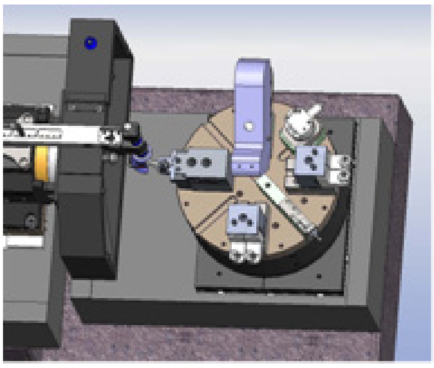
Fast Tool Servo

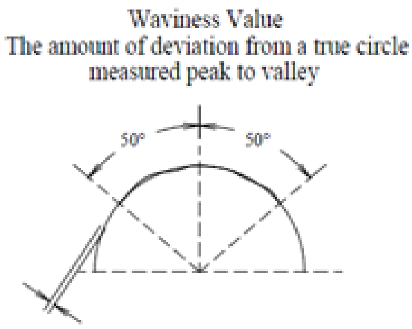
- ◊ FTS receives input of the slide and spindle positions and calculates the tool position in real time while moving X and Z tools through a part program. The tool position is then commanded to the FTS controller, which closes the servo-loop

Prodcuts developed using FTS

Use of non-controlled Waviness Tool by using Hydro-round CNC B Axis

- ◊ Rapid manufacture
- ◊ Selective use of diamond tools
- ◊ Reduced subsurface damage and improved yields
- ◊ Manufacture of steep surfaces
- ◊ Increasing diamond tool utilization
- ◊ Lowering tool maintenance costs

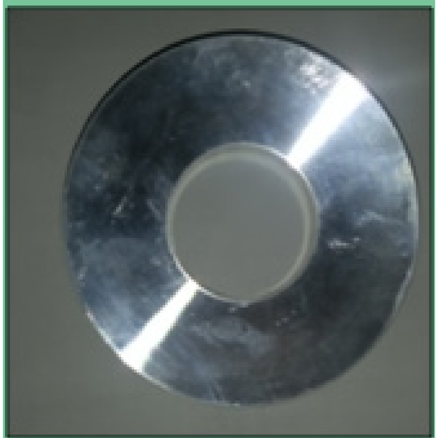




CNC B Axis

Products Manufactured on SPDT Machine

Al alloy mirror



Diffractive Optical Element

Aspheric optics

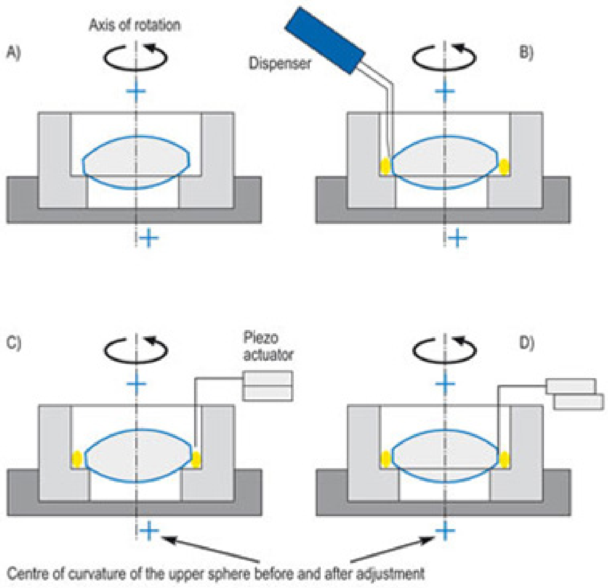
Automated Opto-mechanical Integration Machine

Electro-optical system consists of optical elements to collect light and transfer it to sensing devices. The quality of the image so formed depends not only on the manufacturing accuracy of individual optical elements but also on how accurately these optical components are placed relative to each other during assembly. According to one of the prominent British optical engineer RudolfKingslake,"surface tilt does more damage to an image than any other manufacturing error, therefore in assembling a lens it is essential to avoid tilting the surfaces at any cost."

Based on the requirement of high performance EO instrumentation, a latest machine based on technology related to centering, alignment and bonding has been installed for opto-mechanical Integration.

Performance of the electro-optical instrumentation can be further improved, if accuracy in assembling the optics with their mechanical housing can be increased. This state-of-the-art assembly work-station works on latest available opto-mechanical assembly technique both in visible and IR spectrum. This modern assembly work-station uses automated centering ensuring accurate positioning of every optical component according to optical design layout. This work-station also characterize the assembled optical systems in terms of measurement of inter element spacing, centration measurement, Effective Focal Length (EFL), Back Focal Length (BFL), and Modulation Transformation Function (MTF) measurement.

Automated opto-mechanical integration machine



Automated centering and bonding of lens in mechanical mount

TECHNOLOGY FOCUS

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Excellent ☐ Good ☐ Satisfactory ☐ Needs improvement ☐

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Capabilities of the Machine

- ◊ Measurement of centration error
- ◊ Measurement of air spacing and center thicknesses
- ◊ Automated alignment of optics in mechanical housing
- ◊ Automated bonding of optics with mechanical seating
- ◊ On-Axis measurement of EFL, BFL & MTF
- ◊ Spectral wavelength: Visible and MWIR

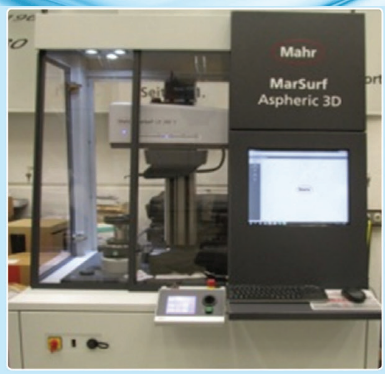
Assembly Procedure of the Machine

- ◊ At first the proper cleaning of both optical and mechanical component is carried out
- ◊ Mechanical housing or barrel axis is aligned with the help of a distance sensor (e.g., a lever gauge) to the axis of the rotary air bearing. The first lens is placed into the barrel
- ◊ Auto-collimator measures the center of curvature position of top surface, w.r.t, the reference axis. Then the lens can be realigned in magnitude and direction according to the measured values.
- ◊ Depending on the mechanical design of the sample the lens is fixed in position, e.g., by using retaining rings or adhesive
- ◊ This procedure of step-by-step measurement, alignment and fixing is iteratively repeated for all further lens elements until the optical system is completed

Other Facilities

Plasma Assisted Coating System

CNC Optical Polishing Machine



Stylus Profilometer

5-Axis CNC Machine

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डेसीडॉक द्वारा प्रकाशित

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