Curriculum Vitae of Dr. A. K. Nath

Full Name	:	Ashish Kumar Nath
Date of birth	:	10/01/1953
Education	:	Ph.D.(Physics, Bombay University, India) 1982
Designation	:	Professor (*Feb. 2007- June 2018*) Visiting Professor (*July 2018-Till date*) Principal Investigator, IMPRINT Project 6917, Co-Investigator, DHI Centre of Excellent of Advanced Manufacturing Processes, Technical Advisor, Paninian India P. Ltd.
Affiliation	:	Department of Mechanical Engineering Indian Institute of Technology, Kharagpur, India Email address: aknath@mech.iitkgp.ac.in; nath.ashishk@gmail.com; Mob. No.: +91-9932199975

Previous Affiliations:

May 1986- Feb. 2007	:	Senior Scientific Officer (SOH^{+}) Raja Ramanna Centre for Advanced Technology, Indore Madhya Pradesh, India
Aug. 1972- Oct.1982 *Nov.1984 – Apr. 1986*	:	Scientific Officer, BARC, Mumbai, India
Nov. 1982 – Oct. 1984	:	Post-Doctoral Research Fellow, Uni. of Alberta, Canada
Specialization & Research Interests	:	High power lasers and their industrial applications, Laser materials interaction and processing, *viz*. welding, surface hardening, cladding, Underwater Laser machining, Laser shock peening, Laser additive manufacturing. Hybrid Laser Cold Spray Deposition Electron beam welding, Electrical Discharge machining
No. of Ph. D. guidance	:	12
No. of Patents	:	04
No. of publications	:	04 Book Chapters & 170 publications in Journals,

Brief description of research work:

2007- Till date: Department of Mechanical Engineering, IIT Kharagpur

R&D on laser material processing applications:

- Fiber Laser cutting, drilling, welding, surface hardening and cladding, Laser Metal forming,
- Water-assisted laser material processing and Water-jet assisted underwater cutting
- Laser Additive Manufacturing- Online process monitoring and control
- Laser Shock Peening * Hybrid Laser Cold Spray Deposition
- Electron beam welding * Electrical Discharge Machining

Ongoing projects:

Sr. No.	Project Title	Role	Sponsoring Agency	Amount Rs. Lakhs	Date of completion
1.	Indigenous development of online process monitoring of laser surface hardening, cladding and additive manufacturing and studies on dynamic mechanical behavior of manufactured parts (Project no.: 6917)	PI	MHRD + DHI (IMPRINT-I)	396.00	14/05/2020 (36 months)
2.	Laser surface treatment of martensitic stainless steels	PI	Sulzer India P. Ltd.	17.11	30/6/2020 (12 months)
3.	Selection of raw materials for additive manufacturing applications in relation to the design require- ments; and life cycle analysis of additive manufacturing process for different materials	Co-PI	DHI	324.84	27/12/2022 (60 months)
4.	Exploring solutions for various technological challenges in metal additive manufacturing technology and sharing the relevant know-how with indian heavy engineering industries	Co-PI	DHI	499.40	27/12/2023 (72 months)
5.	Laser processing of materials	Co-PI	Various	5.0	31/3/2023

List of patents filed:

1. Title of the invention: Crack control in dissimilar welding
   Indian Patent Application No: 201931001618, Jan. 14, 2019
2. Title of the invention: Water assisted underwater direct laser welding method and processing set-up, Patent Application (IPR/BBS/SMS-10/19), May 27, 2019
3. Title of the invention: Direct Additive Laser Welding of Dissimilar Materials
   Indian Patent Application No: 202031000073, Jan. 01, 2020
4. Title of the invention: Real-time monitoring and control of thermal history using multiple pyrometers for laser material processing including additive manufacturing processes, Indian Patent Application No.: 202031001870, Jan. 15, 2020

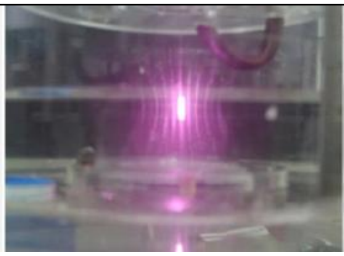
Pictorial representation of some of the Research Activities carried out at IIT Kharagpur

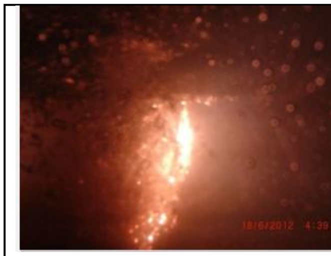
2kW Fiber Laser


Fiber laser beam coupled to 5axis CNC worktable

Fiber laser cutting

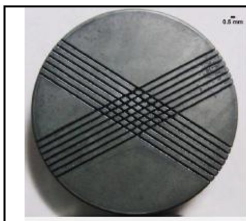

With & Without Striations laser cutting

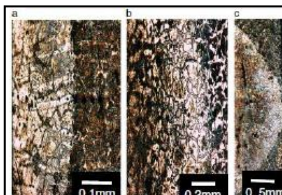

Fiber Laser through water


Gas-jet assisted underwater laser cutting

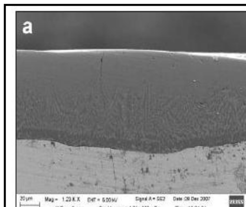

Water-jet assisted underwater laser cutting


Laser Metal Forming


Water-jet assisted Laser Silicon Scribing



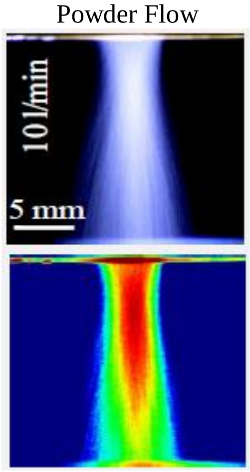
Laser surface hardening by repetitive laser pulses



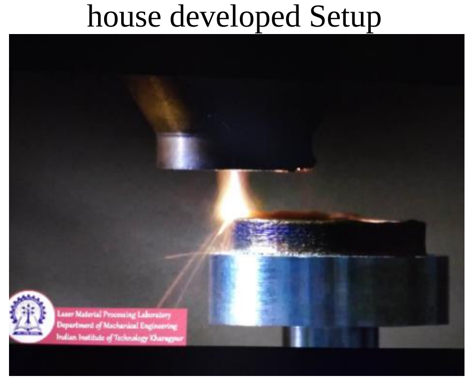
Multi-component hard nano ceramic coating

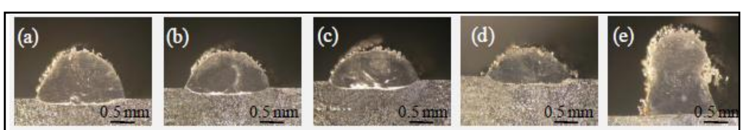
Laser Cladding head

Powder Flow



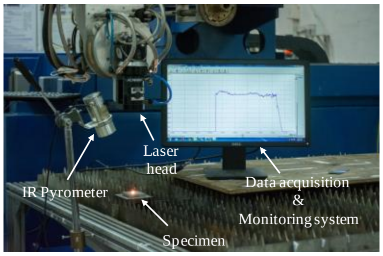
Laser Additive Manufacturing with In-house developed Setup

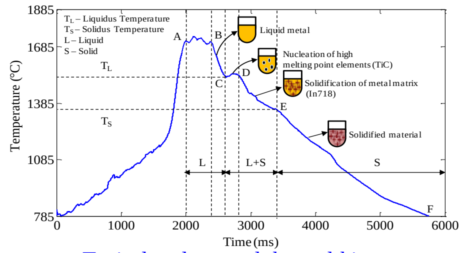




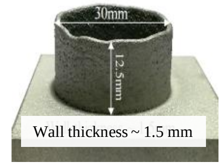
Blown powder laser cladding at different scan speeds

Online monitoring of molten pool thermal history and additive manufacturing by in-house developed setup

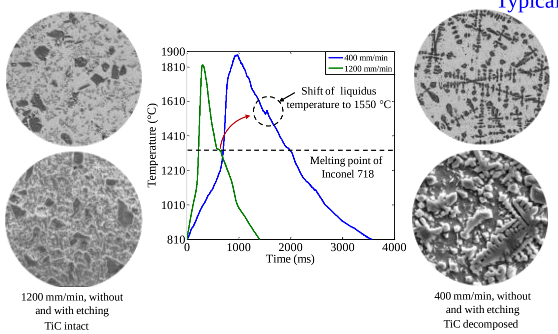




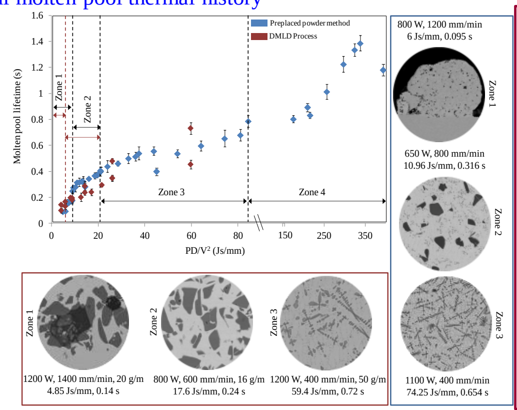
Typical molten pool thermal history



AM of IN625 cylinder using in-house developed setup



Shift in liquidus temperature location & change in solidification shelf slope acts as a sign of compositional change

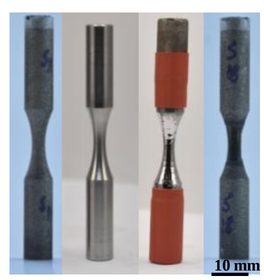


Versatile for deposition by any method i.e. powder bed or blown powder method

Effect of build orientations, surface modifications & heat treatment on tensile strength and fatigue life

Fig. As-built and vertical cylindrical bars

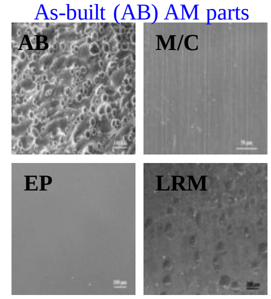
Fig. Horizontal cylindrical bars

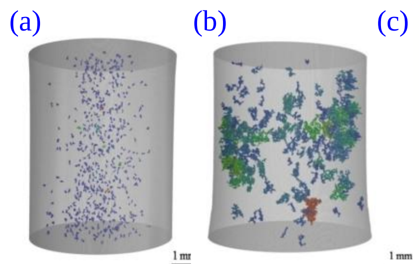


As- built (AB) vs. Machined (M/C) vs. Electro-polish (EP) vs. Laser re-melting (LRM)

Type	Ra value	Fatigue life
M/C	~ 92.2 %	~ 138%
EP	~ 97.4 %	~ 100 %
LRM	~ 91.2%	~ 119%

Performance assessed w.r.t As-built (AB) AM parts

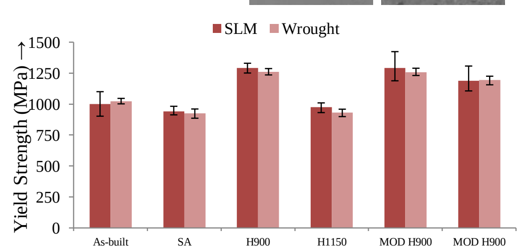




Colour coding for defect volume (mm³) -Blue: <15E-4; Green: 15E-4 – 35E-4; Orange: 35E-4 – 50E-4; and Red: >50E-4

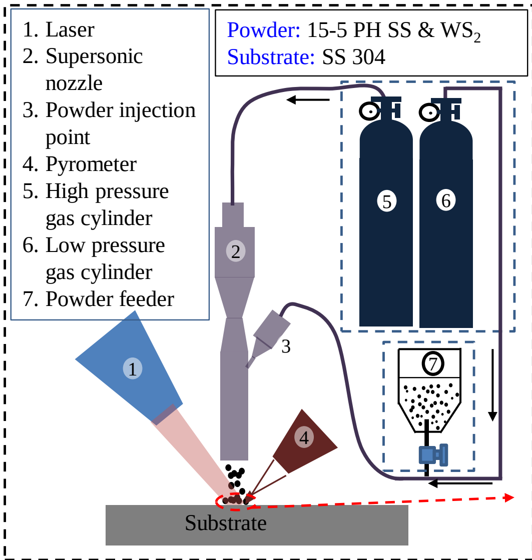
Vertically built Horizontally built

Fig. Micro-CT analysis showing defects in as-built (a) vertical,(b) horizontal SLM specimens and (c) stress concentrations around defects for these two cases

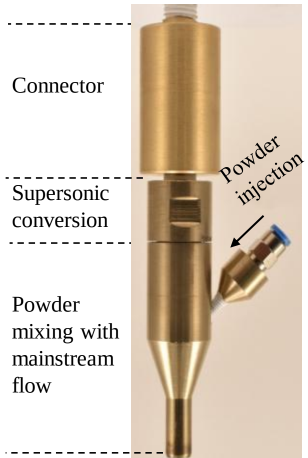


Variation in tensile strength with different heat treatment

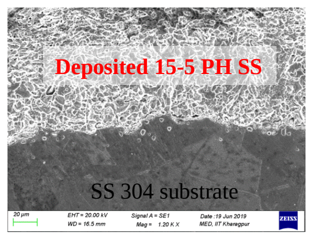
Indigenous development of laser assisted cold spray process



Schematic of Laser Assisted Cold-Spray (LACS) set-up



In-house fabricated LACS nozzle



Cross-sectional view of the coating generated by LACS process

Cold spray process

Impingement of powder with supersonic velocities on substrate → sudden plastic deformation of powders → coating by solid state diffusion

Difficulties in cold spray

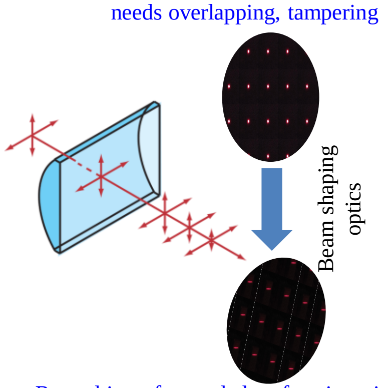
- Powder velocity> 2 Mach
- Weak bonding & High porosities

Advantages of LACS process

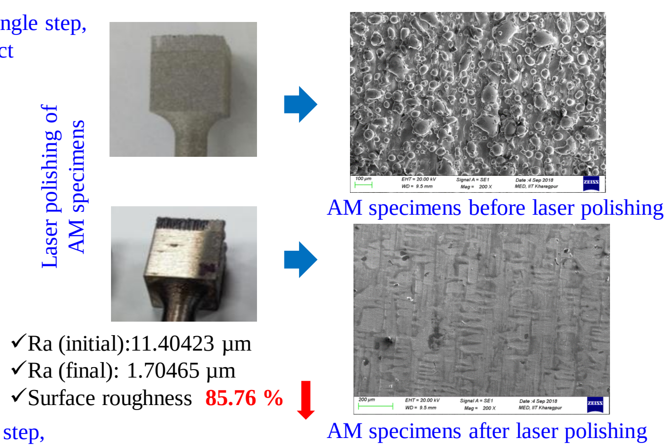
- Deposition at 1-1.5 Mach velocity
- Deposition of low dissociation temperature powders
- Powder property unaffected
- Strong coating bonding
- No dilution
- Negligible porosity
- Economical than cold spray

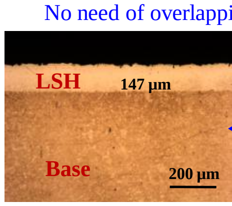
Laser beam shaping and its applications in surface polishing and transformation hardening of industrial components

Difficult to re-melt extended surface in a single step, needs overlapping, tampering effect

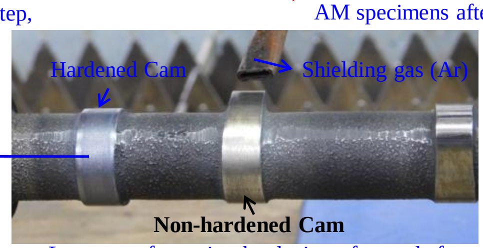


Re-melting of extended surface in a single step, No need of overlapping





Optical micrograph of hardened zone



Laser transformation hardening of cam shaft

Depth of modification ~ **150 µm**

Hardness **increased** from **380 HV to 980 HV (max)**

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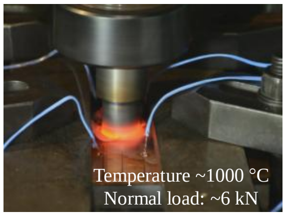
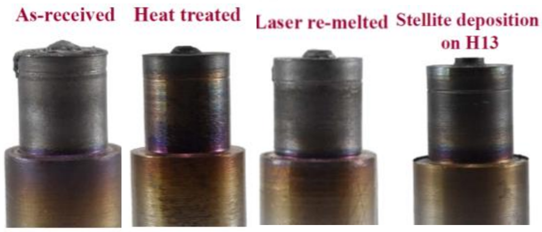
Industrial applications of laser cladding / Additive Manufacturing

Development of Friction Stir Welding (FSW) tools by Direct Metal Laser Deposition for high temperature applications



FSW of Cu-Cr-Zr with Stellite deposited H13 tool

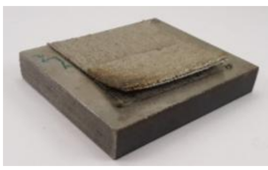


Different types of FSW tool

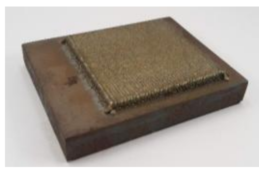
Tool performance

- Tool tips **deformed** in case of as- received, heat treated and laser re-melted cases after 125 mm weld pass.
- Stellite deposited on H13 tool **remained intact** even after 1000 mm of weld pass

Substrate pre-heating to avoid delamination in multi-layer deposition



Without substrate pre-heating



With substrate pre-heating (~ 370 deg C)

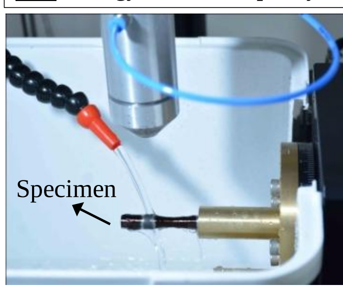
Refurbishment of gear using Laser Additive Manufacturing

Broken gear teeth

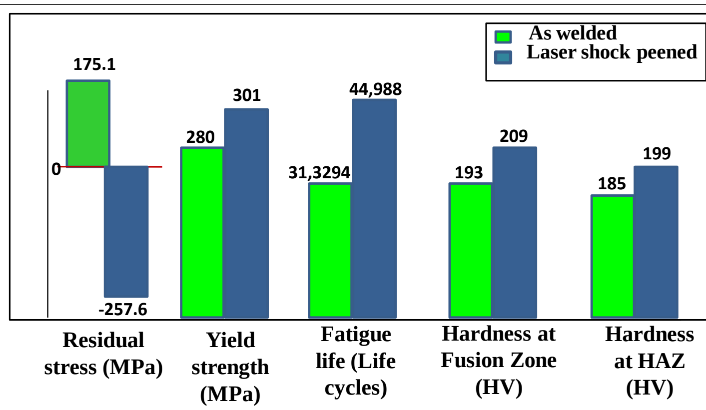
Refurbished gear

Enhancement of hardness, mechanical strength and fatigue life of electron beam welded titanium by Laser Shock Peening (LSP)

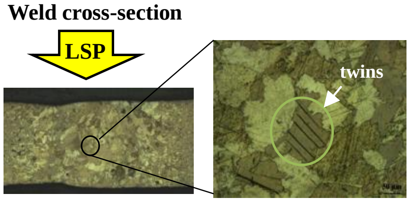
LSP: Energy = 0.8 J, Frequency = 10 Hz, Pulse = 10 ns, Beam diameter = 1.5 mm, water layer thickness = 1 mm



LSP process



Weld cross-section



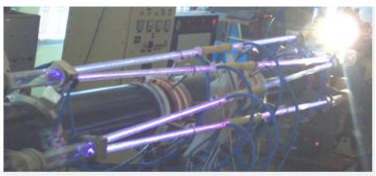
Enlarged view

- **Laser shock peening led to the formation of twins within grains along with decrease in grain size.**
- **Laser shock peening induced compressive residual stress along with enhancement in mechanical strength, fatigue life and hardness of the weld zone.**

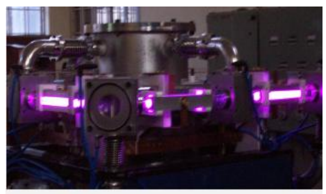
1986-2007: Raja Ramanna Centre for Advanced Technology, Indore M.P, India;

- R&D of high power lasers and their scientific and industrial applications;
- Developed line tunable TEA pulsed CO_2 laser of average power up to 500W,
- CW CO_2 lasers of power up to 15 kW,
- High power solid state lasers (at fundamental wavelength and higher harmonics), and
- The first semiconductor diode bar laser in the country,
- A laser rapid manufacturing setup integrating one of the indigenously developed CW CO_2 lasers and co-axial powder feeder with a 5 axis CNC machine,
- Wide variety of laser material processing applications: Cutting, welding, surface modifications, rapid manufacturing, laser isotope separation, and nano particle synthesis etc.

The photographs show the various laser systems indigenously developed under the guidance of Dr. Nath.



400W Diffusion Cooled CW CO_2 Laser



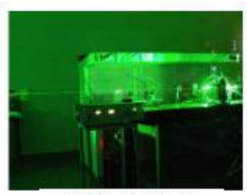
1kW FAF CW CO_2 Laser

3.5 kW CW CO_2 Laser with CNC Workstation

20kW CW CO_2 Laser

Hi-rep-rate TEA CO_2 Laser

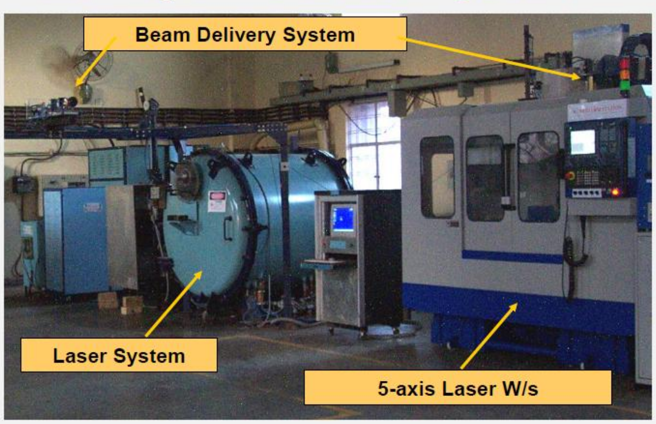
Diode pumped high power Nd:YAG Laser



Diode pumped Green Solid –State Laser

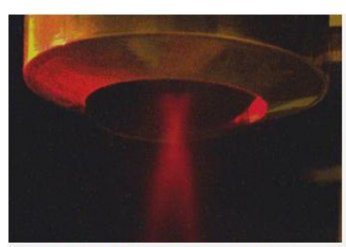
Laser Photo-coagulator

Laser Rapid Manufacturing Station

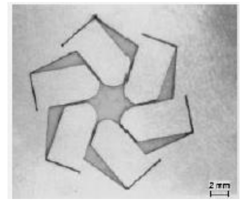


5-axis vertical Machining Center is integrated with powder feeder, co-axial nozzle & beam delivery systems.

Side Powder Feeder



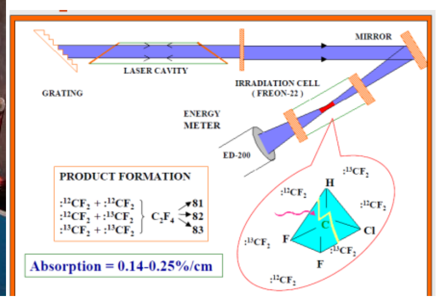
Coaxial Powder Feeder

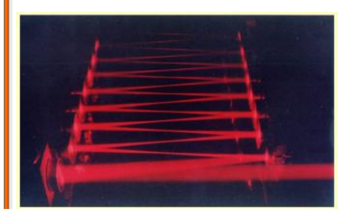


Laser cutting of Ti sheet

Laser welding of Gears

TEA CO_2 Laser ^{13}C isotope separation in a Multi-pass Linear Cell





1982-'84: Department of Electrical Engineering, University of Alberta, Edmonton, Canada,

- R&D of multi-kilowatt PIE CW CO_2 lasers

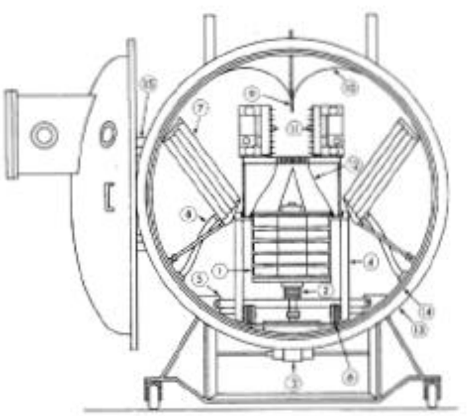


Fig. 1. Schematic diagram of 10 kW PIE CW CO_2 laser. (1) Axial flow compressors. (2) Polyflex belt drive. (3) Hydraulic motor. (4) Compressor-array chassis. (5) Chassis tie pins. (6) Chassis roll out track. (7) Heat exchanger. (8) Water cooling lines. (9) Ceramic flow splitter. (10) Flow ducting. (11) Fluid-ballasted multielement electrodes. (12) Compressor flow transition. (13) Laser tank door flange. (14) O-ring vacuum seal. (15) Door hinge.

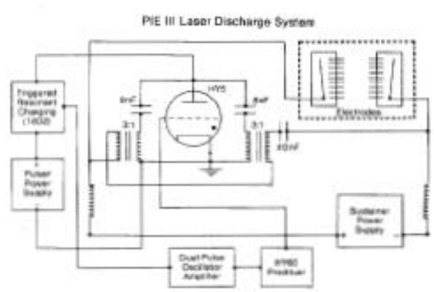


Fig. 2. Electrical schematic of pulser.

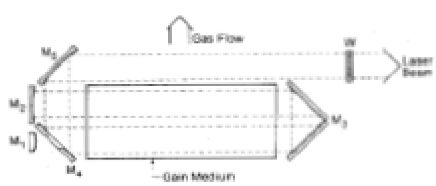


Fig. 3. Diagram of folded path unstable resonator.

1972- ’82 & 1984-‘86: BARC, Mumbai, India,

- R&D of high power TEA CO_2 lasers, single longitudinal mode, line tunable and multi-rotational line operations;
- Selective laser isotope separation studies with high repletion rate TEA CO_2 laser

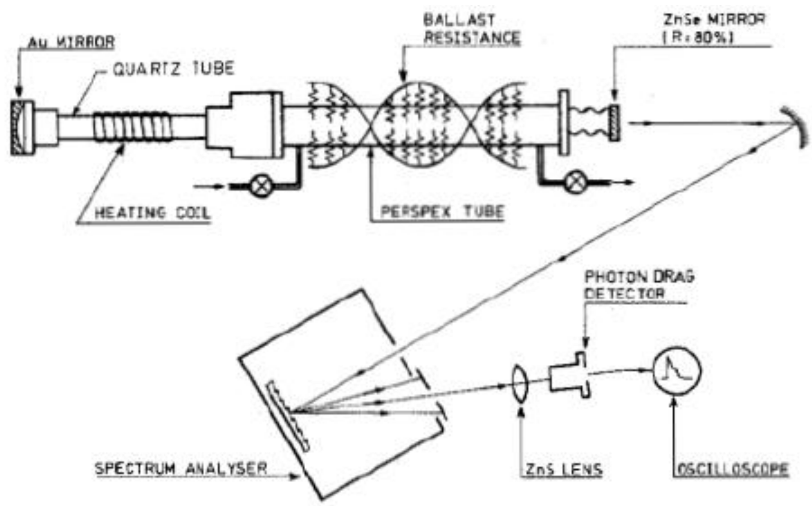


Fig. 1. Schematic diagram of the experimental arrangement.

Simultaneous Multi-rotational line operation of a TEA CO_2 Laser (IEEE JQE, 16, 11, 1980)

List of Publications:

Book Chapters:

1. A K Nath, High Power Lasers in Material Processing Applications: An Overview of Recent Developments, Pages 69-111, Laser-Assisted Fabrication of Materials, Editors: **Majumdar**, Jyotsna Dutta, **Manna**, Indranil , Springer Series in Materials Science, 2013, Springer-Verlag Berlin Heidelberg, DOI10.1007/978-3-642-28359-8
2. A.K.Nath, 9.06 - Laser Drilling of Metallic and Nonmetallic Substrates, Reference Module in Materials Science and Materials Engineering, Comprehensive Materials Processing Volume 9, 2014, Pages 115-175, https://doi.org/10.1016/B978-0-08-096532-1.00904-3
3. Ashish Kumar Nath, Sagar Sarkar Laser Transformation Hardening of Steel (Invited Book Chapter) *Advances in Laser Materials Processing (2nd Ed.) edited by J. Lawrence,Woodhead Publishing, Elsevier* Chapter 11 (2017)
4. Ashish Kumar Nath, Shitanshu S. Chakraborty, Sagar Sarkar, Gopinath Muvvala, Suvradip Mullick, Yuvraj K. Madhukar, Debapriya Patra Karmakar LASER based manufacturing as a green manufacturing process (Invited Book Chapter) *Sustainable Material Forming and Joining,CRC Press/Taylor and Francis group* Chapter 15 (2018)

Journals:

1. Abhijit Sadhu, Amit Choudhary, Sagar Sarkar, Amal M. Nair, Pravanjan Nayak, Sagar Dadasahed Pawar, Gopinath Muvvala, Surjya K. Pal, Ashish Kumar Nath, A study on the influence of substrate pre-heating on mitigation of cracks in direct metal laser deposition of NiCrSiBC-60%WC ceramic coating on Inconel 718, Surface & Coatings Technology 389 (2020) 125646, https://doi.org/10.1016/j.surfcoat.2020.125646
2. Abhijit Sadhu, Debapriya Patra Karmakar, Omkar Mypati, Gopinath Muvvala, Surjya K. Pal, Ashish Kumar Nath, Performance of additive manufactured Stellite 6 tools in friction stir processing of CuCrZr sheet, Optics and Laser Technology 128 (2020) 106241, https://doi.org/10.1016/j.optlastec.2020.106241

3. Debapriya Patra Karmakar, Gopinath Muvvala, Ashish KumarNath, Effect of scan strategy and heat input on the shear strength of laser cladded Stellite 21 layers on AISI H13 tool steel in as-deposited and heat treated conditions, *Surface and Coatings Technology, (384) 25 February 2020, 125331, https://doi.org/10.1016/j.surfcoat.2019.125331*
4. Sagar Sarkara , Shreya Mukherjeeb , Cheruvu Siva Kumara , Ashish Kumar Nath, Effects of heat treatment on microstructure, mechanical and corrosion properties of 15-5 PH stainless steel parts built by selective laser melting process, *J Manufacturing Processes 50 (2020) 279–294, https://doi.org/10.1016/j.jmapro.2019.12.048*
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