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Proposal For

INTERDISCIPLINARY MATERIAL

CoE

CENTER OF EXCELLENCE FOR INTERDISCIPLINARY MATERIAL CHARACTERISATION
For VISVESVARAYA TECHNOLOGICAL UNIVERSITY (VTU)

Prepared
Organization Name: VISVESVARAYA TECHNOLOGICAL UNIVERSITY

5th May 2020

To,
The Vice Chancellor,
Visvesvaraya Technological University (VTU)
Jnana Sangama, VTU Main Rd, Visvesvaraya Technological University,
Machhe, Belgaum, Karnataka 590018
.

Proposal for Centre of Excellence in Interdisciplinary Material Characterization

Dear Sir,

The Material testing market in India is projected to grow at a robust CAGR during 2019-2023. The major factors contributing to the growth of the market are growing research activities, increasing demand from automotive, aerospace construction & educational institutions, industries and increasing demand of light weight & advanced materials.

Educational Institutions are the largest end-use industry, owing to the research activities carried out by research scholars to develop high-quality materials at a cost-effective price. Moreover, project funding from government and private organization to develop and analyze material quality for better suitability of specific applications increases the usage of material testing in educational institutions.

Nanatom is very keen to offer the next generation material characterization technology enablement and adoption programs to Visvesvaraya Technological University (VTU) for a period of 3-years to skill the next generation engineering and inculcate research cum innovation culture.

- Material testing for steel, mining, glass and ceramic industry.
- Material testing for mechanical, electronics, electrical, nanoscience, metallurgical and semiconductor depts.
- Material testing for biomedical industry, medical and dental colleges.
- Technology incubation to start-ups and Industry Innovation Center @ district headquarters.

Assuring you best of our services to ensure the CoE's are a very successful engagement yielding the desired results for students and people of Karnataka and nearby states.

Thanking you,
Yours truly,

Satish Kumar R
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ABOUT US

Nanatom Technologies

We are excited to introduce our technology start-up "Nanatom Technologies Private Limited". Nanatom is headquartered in Bangalore, India and through extensive research developed precision Nano and Micro Material Characterization Systems and Micro-mechanical In-Situ Test Stages for SEM, XRD and optical microscopes.

Our mission is to "Support and empower our students and scientists to be world leaders in new material development, characterization and application testing".
Our cutting-edge technology has been incubated and undergone lengthy and rigorous testing in the one of the most reputed scientific institutions in India - Indian Institute of Science, Bangalore.

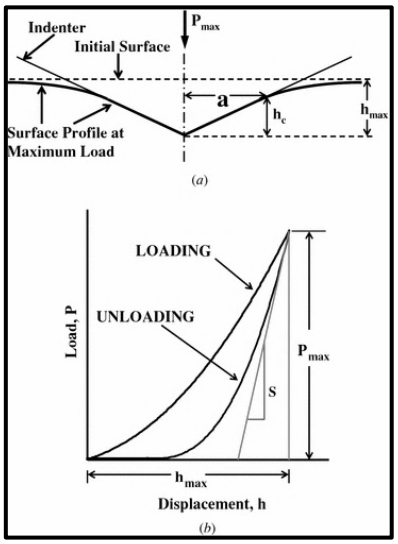
We are proud to be an Industry partner for an IMPRINT-II project proposed by dept. of Mechanical Engg. IISc. Bangalore.

Nanatom believes that the indigenous development new age material testing technologies will provide the right exposure to our students on cutting edge product development and eventually put the future scientists of India in complete control of new material development process.

TECHNIQUES

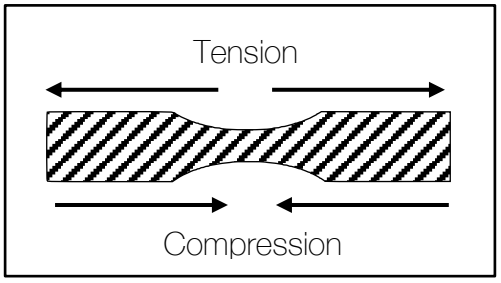
IIT – Instrumented Indentation Test

- Instrumented indentation testing is a popular technique for measuring the mechanical properties of materials.
- IIT is particularly well suited for testing small volumes of material such as thin films, particles, or other small features.
- IIT is used to measure complex modulus in polymers and biomaterials, yield stress and creep in metals, and fracture toughness in glasses and ceramics.
- IIT is used to measure mechanical properties at the nanometer scale. It is an essential tool for evaluating films, coatings, and surface layers which are used to improve mechanical performance and longevity.
- IIT is the simplest and fastest type of characterisation because
  - sample preparation is relatively easy
  - hundreds of tests can be performed on a single sample



Tension Test

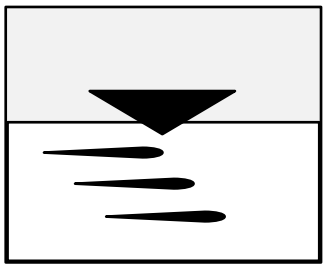
- A tensile test, also known as a tension test, is one of the most fundamental and common types of mechanical testing. It applies pulling force to a material and measures its response to the stress. Tensile tests determine how strong a material is and how much it can elongate. They are standardized under ISO and ASTM standards.
- A lot can be derived about a material from tensile testing. By measuring the material while it is being pulled, we can obtain a complete profile of its tensile properties. This data results in a stress/strain curve which reflects the materials reaction to forcce.
- The point of failure is of interest including the modulus of elasticity, yield strength, strain and UTS.



Compression Test

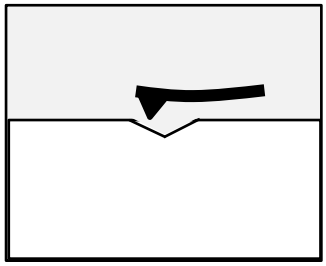
- Like a tensile test compression testing is a fundamental type of mechanical test.
- Compression tests are used to determine a material's behavior under applied crushing loads, and are typically conducted by applying compressive pressure to a test specimen using fixtures.
- Various properties of the material are calculated and plotted as a stress-strain diagram which is used to determine qualities such as elastic limit, proportional limit, yield point, yield strength, and, for some materials, compressive strength.
- Compression testing allows testing the integrity and safety of materials, components, and products during several phases of the manufacturing process.
- Materials that exhibit high tensile strength tend to exhibit low compressive strength. Likewise, materials high in compressive strength tend to exhibit low tensile strength.

Scratch Test



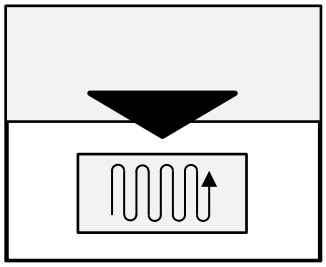
- Scratch testing is carried out to get an insight into materials to determine the resistance to abrasion and wear.
- During a Scratch Test, an indenter or a tip made out of a hard material, is drawn across the coated surface with an increasing load, resulting in various types of failure at specific critical loads.
- Failure points can be determined using frictional force and depth measurements.
- Depth measurements provide the plastic and elastic portion of the deformation. Constant load scratch testing can be used in mapping to check the surface uniformity.
- Scratch testing applications include commercial polymers, paint, and varnishes for the automotive industry, multilayered systems, and application-related performance.

AFM – Atomic Force Microscopy



- Atomic Force Microscopy is a specialized scanning probe microscopy technique to observe surface morphology which is an important property for many high-tech surfaces with features that can go down to a few nanometers and surface roughness well below a nanometer.
- Topographic and Surface roughness measurements.
- Scanning methods for advanced imaging modes.
- AFM can characterize a wide array of mechanical properties (e.g. adhesion, stiffness, friction, dissipation), electrical properties (e.g. capacitance, electrostatic forces, work function, electrical current), magnetic properties, and optical spectroscopic properties.
- In addition to imaging, the AFM probe can be used to manipulate, write, or even pull on substrates in lithography and molecular pulling experiments.
- Force spectroscopy.

Wear Test



- Multi-pass wear tests allow the investigation of nano-wear and micro-wear in a predefined region of interest. This is done using a conventional nano indenter probe and by moving it perpendicular to the sample whilst the contact is either held constant or ramped at a progressive rate.
- Throughout the test the probe penetration depth and tangential force are acquired.

Dynamic Mechanical Test

Dynamic Mechanical Analysis (DMA) is a technique that is widely used to charecterize a material's properties as a function of temperature , time Frequency , Stress , Atmosphere or a combination of these parameters .

Fatigue Test

Many applications exist where a material is subjected to a repeated cyclic stress. These materials are found to fail after a large number of applications of the stress even though the cyclic stress that is applied is below their yield strength. This mode of failure is termed fatigue.

The reason that these materials fail is due to progressive stepwise crack growth through the sample. Cracks create stress concentrations that raise the level of stress to a level above the yield strength of the material in the vicinity of the crack. Repeated cyclic stresses propagate the crack until failure.

Temperature Test

In order to provide reliable and accurate prediction of mechanical properties scientists are increasingly demanding Materail characterization tests that mimic real – world condictions which in-turn requires characterization at application temperature.

High temperature testing at the nano-scale and micro-scale under true service conditions allows for precise evaluation and optimisation of materials used in high temperature applications, in a time efficient manner.

Properties required for material characterization – hardness modulus, creep when measured at room temperature do not provide an assessable indication of these properties at high temperature.

For applications where temperature is a critical factor observing a change in mechanical properties is vital to predicting material behaviour.

The ablility to directly assess this behaviour at relavant temperatures is an important tool in determining a materails suitability for its final application thus removing guesswork and extrapolation.

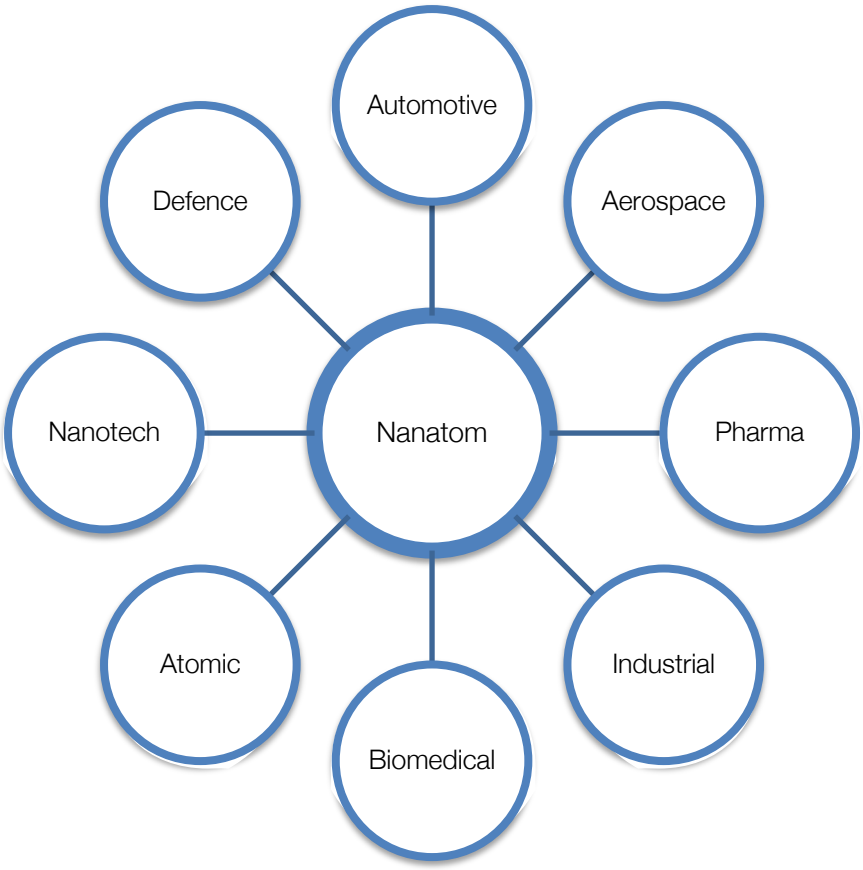
EXCELLENCE

What is Excellence?

Even though times have changed, a race is still on.
The race for being the best in industry, the race for being better than the rest. What are education and research institutes doing differently to ensure that they emerge as winners?

To stand out and surpass competition in the race, these entities need to understand that “expertise” is the key, and Centers of Excellence are instrumental in accelerating in their journey to improve research quality and showcase a deep understanding of a domain.

EXCELLENCE + EXPERTISE = SUCCESS

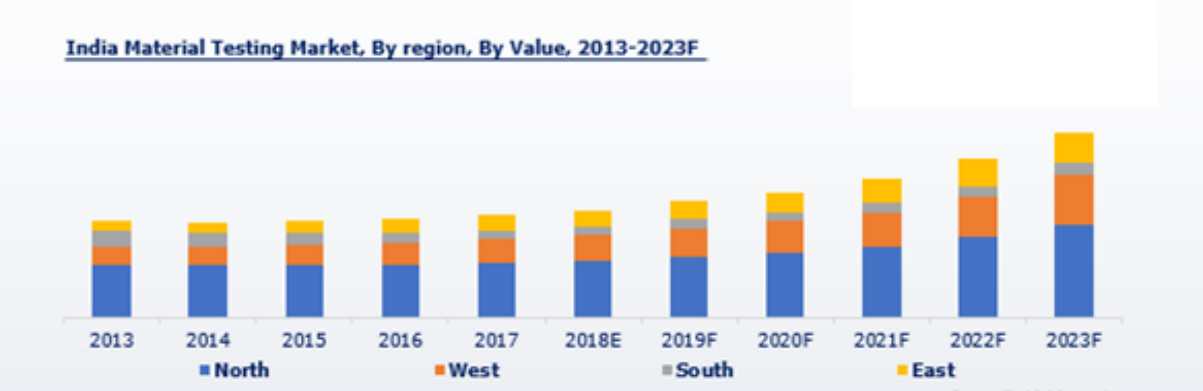


NEED

- Increase in importance to meet manufacturing standards such as the global ISO and ASTM standards for quality specification and testing of different types of materials in various types of applications has created significant demand for material testing.

- Rise in demand for material testing in research organizations and educational institutions is also driving the material testing market. This can also be ascribed to the increase in R&D activities carried out by research scholars for better product developments either individually or in collaboration with industries.

- The prerequisite for development of advanced materials is to meet the regulations with regards to the multiple industry verticals has been intensifying the tests methods on different materials thereby elevating the selection of material testing types & equipment across the industries.



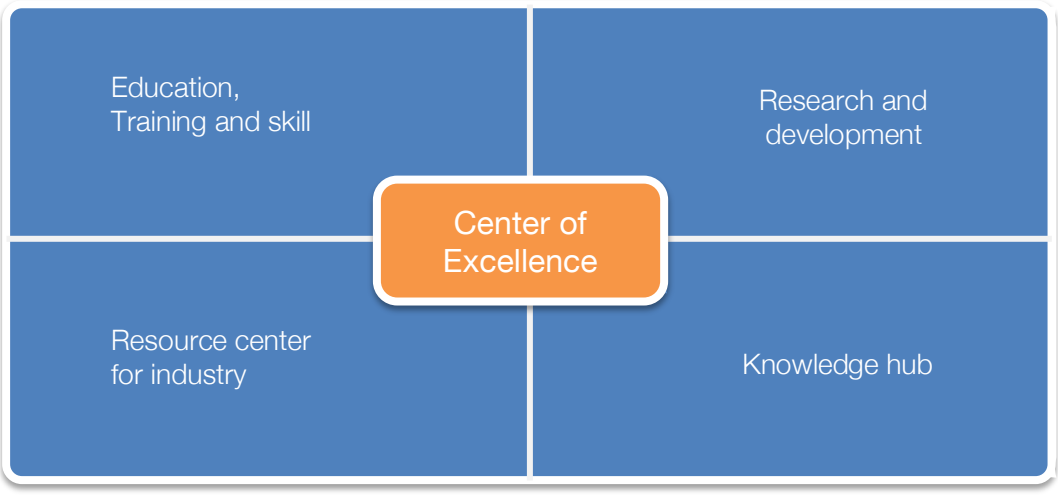
- If industries in Karnataka to compete in international market, Quality Control of manufactured parts is of critical importance. If such quality control is to be achieved, equipment for advanced characterization of materials at the micro and near nano levels are required.

- Further, development of new materials through fundamental research is of critical importance in industry have to be in the forefront of product development. Here too characterization of the material at the micro and near nano scale is important.

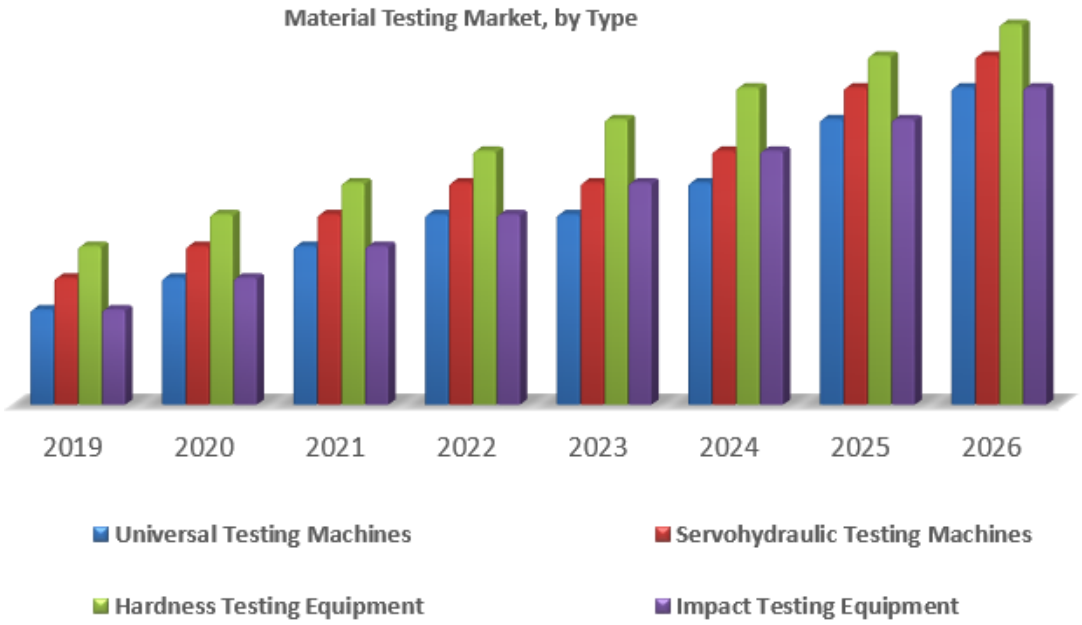
- An instrument with material characterization capabilities at nano and micro scale can also be used for fundamental material research and in the field of Mechanical, Material Science, Physics, Tribology and Electronics.

IMPACT

- Attract talent – faculty, student and industry magnets.
- Develop leadership in specialist areas of science and technology.
- Achieve international recognition of staff and internationally competitive research.
- Help maintain high standards in building research capacities through professionalisation.
- Strengthened the infrastructure in universities and enable the academic community to improve their research quality and publications.
- Improve the quality of training and help build skills.
- Opportunity to upgrade standard curriculum to Curriculum relatable to real world exposure or Curriculum ++.
- In various sectors have resulted in significant improvements in two-way partnerships and collaborations.



MARKET



Growth Dividers

Automotive Industry

The increasing innovations in the vehicle industry with electric vehicles, fuel-cell, hybrid-electric vehicles and integration of AI and IoT requires testing process to pass the product and the material used to ensure the consumers safety. The automotive industry is driving the material testing market.

Medical Devices

The material used for manufacturing of the critical medical devices and equipment requires many analyses before passing the product for sale in the market. The mounting growth of innovations in the medical sectors are giving rise to manufacturing of various medical equipment. The rising quantity of the devices also, demanding the material testing equipment that is influencing development of the material testing market.

Construction Industry

The growing consumers' interest towards modern living and techniques are giving rise to more building and constructions. Furthermore, with advancement in the construction sector the trend of smart homes and security is fueling the demand for testing the quality and other properties of the technology. Different testing is required for every material used in the construction. Therefore, demand for material testing came into existence which is attributed with growth in the material testing market.

BENEFITS

1 ATTRACT HUMAN CAPITAL

CoE's will pave the way to attract and retain the best minds in Karnataka and encourage participation in joint collaborative research in areas of Nuclear, Automotive, Medical and Materials engineering.

2 ATTRACT FINANCIAL CAPITAL

CoE's open doors to attract strategic investments from Venture Funds and Foreign investors to fund Start-up Technology and Hi-Tech companies in the field of Engineering and Design, Material Development.

3 RECOGNITION

This eco system created by Visvesvaraya Technological University (VTU) with nearby Industries will create accolades and recognition for providing such a facility to solve their real time issues with testing. Visvesvaraya Technological University (VTU) will become a catalyst to resolve future problems, improvise existing product lines and quality and provide a window of opportunity for students to work with Industry may be as an internship or a full fledge project as part of the curriculum.

4 JOB OPPORTUNITIES

This eco system created by CoE's will provide a window to generate job opportunities due to the interaction with Industry and high degree of exposure for research students. Establish Visvesvaraya Technological University (VTU) as the Global Education and Research Hub in the Asia pacific region for Research, Engineering & allied fields by creating avenues for collaborative research.

COMPARISON

Traditional hardness testers employ deadweight systems, to apply and hold the test force.

Deadweight, or open-loop, testers utilizes a series of incremental, stacked weights to apply the test force at the indenter. Minor loads are applied by spring or small weight.

Large operator influence due to parallax errors and optical aberrations.

Traditional Characterisation Hardness Test	Modern Characterisation Instrumented Indentation +
Large uncertainty in the optical length measurement for low loads and penetration depths	Sensor data used to determine mechanical properties without having to image the hardness indents, removing uncertainties related to optical measurement
Large operator influence due to parallax errors and optical aberrations. Low repeatability	No operator influence due to automated measurement method. High repeatability
Dark, dull and highly reflective surfaces require elaborate material pre-treatment for effective optical measurement	Errors caused by uneven lighting, dark, dull or highly reflective surfaces do not influence measurements
Fixed target loads and load rates	Allows application of specified force or displacement which is controlled and measured simultaneously and continuously over a complete indentation cycle
Custom load control profiles not available	Allows custom load control and displacement control profiles during an indentation cycle. This gives the user extreme flexibility to customize test routines
Hardness value is solely a measure of plastic material properties. No information on elastic or visco-elastic properties available	Mechanical properties such as hardness, elastic modulus, relaxation modulus, creep and tensile properties can be obtained and many other derivative studies can be conducted by analysing the indentation force–depth curve
Cannot be used on elastic materials where imprint left by indent is very small because of elastic recovery	Can be used to probe the mechanical response of materials from metals and ceramics to polymeric and biological materials
Cannot be used for thin films and coatings as low load measurements are prone to large errors	Measurement of thin film coatings without the influence of the base material
Load range of measurements are limited. Typically from 5 gm to 1 kg	Load range from 1 mg to 1 kg is possible

SOLUTION

Materials Characterization ***SUPERLAB***

1. COE Overview and Goals
2. Total product Portflio offering
    - Product Description: FoundatiONE Material Characterisation Platform, TRAVIX In-situ test platform
    - Department Mapping – Mech, Automotive, Civil, Electronics, Materials, Life Sciences, Nano Science, Biotech, Medical - with real world examples.
    - Syllabus, benefits, exposure to MSME, get the jobs, Advantages compared to existing system
    - Project
    - Research Areas
3. Value Addition – Competancy Development
    - Training
    - Instrument Manager
    - Account Manager
    - Backend Technical Support
4. Revenue Model: Tangible and intangible revenue, Reserach Grants, Combined projects revenue, Digital marketing.
5. Research Application
6. Establish a Material Characterization SUPERLAB
    a. 3-year engagement model.
    b. Industry engagement program
        i. Industry Expert Talk & Visiting faculties, 2 / yr – IITs / Nanatom / Industry leaders.
        ii. Industry Resource Training, 4 days / yr – IITs / Nanatom / Industry leaders.
    c. Student development program
    d. Certification for 50 students
7. Faculty development program
    a. MATCHAR-CHAMPION program for 5 faculty members
8. Institute development program
    a. Research & Development initiatives
    b. Student Innovation Center
    c. Student Competition guidance
    d. Internship Support
9. System and space requirements
10. Activities and Outcome
11. Pricing and CoE Investment from stakeholders

PROGRAM

- **Embedding Material Testing as part of Research / Engineering**: Central Instrument Facility by Nanatom shall enable Engineering / PG / Ph.D. students in testing advanced and emerging materials in interdisciplinary areas.

- **Exposure to Students**: Nanatom shall facilitate testing, projects and thesis to students to adopt various testing technologies and exposure to cutting edge product development process.

- **Innovation Center**: Integrating material Testing in research activities, building certified Engineering test labs through adopting perfect testing products in Do-It-Yourself setups so that the students get hands on and develop expertise in faculties to create future ready engineers

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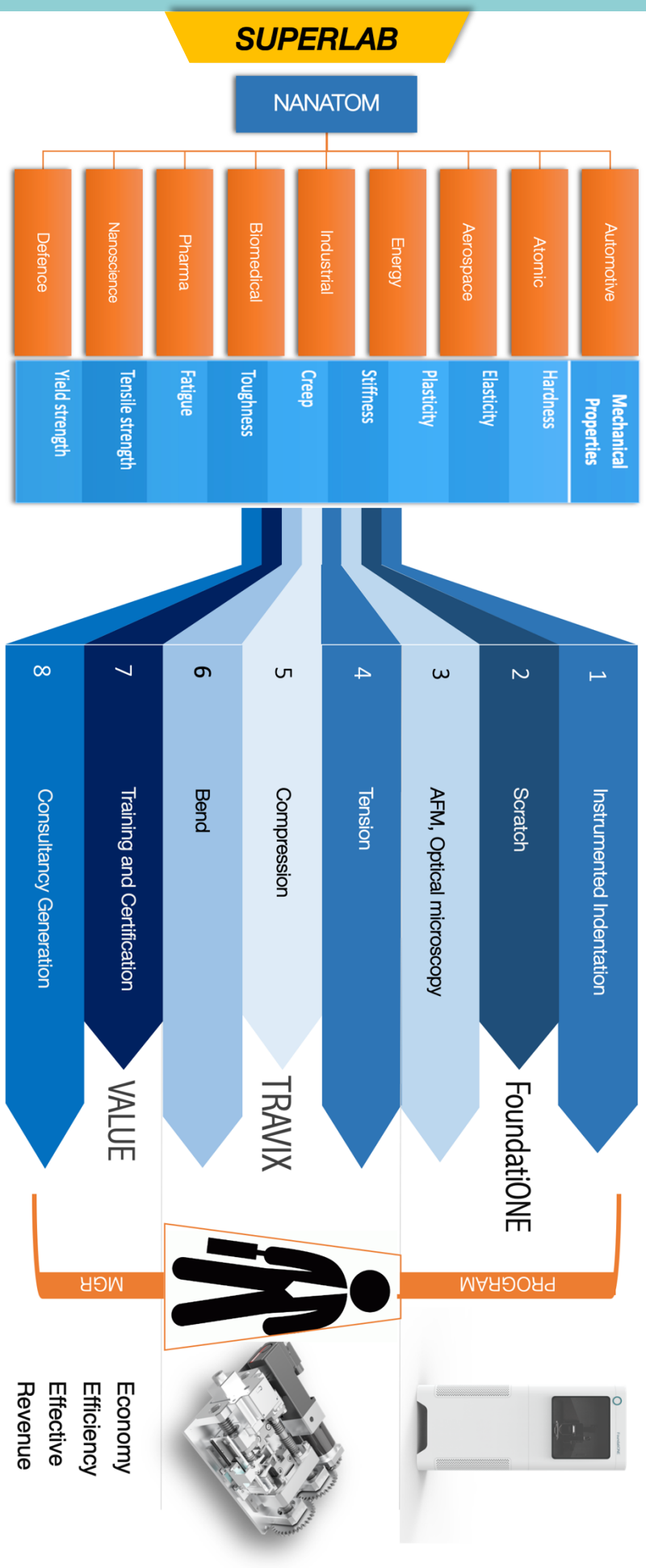
- **Incubation & Testing Centers**: Developing Industry ready test centers will cater to the needs of startups, Defence and Aerospace institutes like DRDO and ISRO labs.

CENTER OF EXCELLENCE

INTERDISCIPLINARY MATERIAL CHARACTERISATION



INSTRUMENTS

Nano, Micro - Mechanical test platform

IIT, Scratch, AFM, Optical Microscope

FoundatiONE™

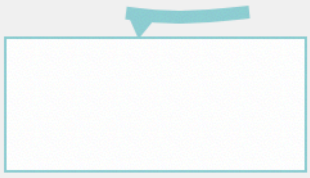
Multi-role multi-scale Material characterization system

Modular, precise and robust, ready to match your growing material test requirements

Nanoindentation

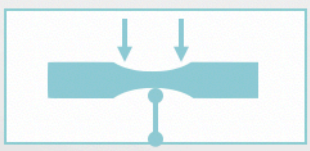
Elevated temp testing

Scratch



AFM

Tension, Compression

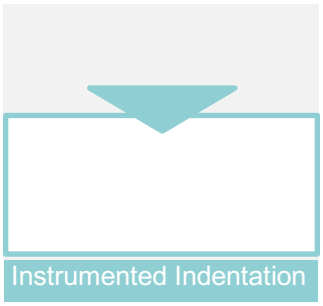


3 / 4 Point Bend

FoundatiONE™

Nanatom's Integrated multi-role multi-scale mechanical test platform. FoundatiONE is modular, precise and robust - ready to match your growing material test requirements

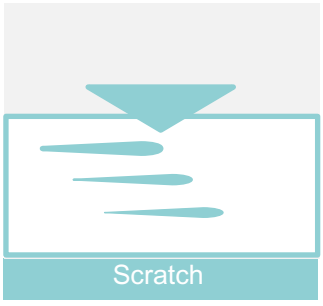
FoundatiONE is capable of performing MULTIPLE Nano AND Micro Mechanical tests on a wide range of materials – metals, alloys, fibers, composites, polymers, plastics, ceramics, thin films, biomaterials, GELS,



Scale - nano, micro

Measures mechanical properties from the sub-nano to micro scale. Used for evaluating films, coatings, and surface layers which are used to improve mechanical performance and longevity.

IIT is one of the simplest and fastest types of mechanical testing, because sample preparation is relatively easy and hundreds of tests can be performed on a single sample.



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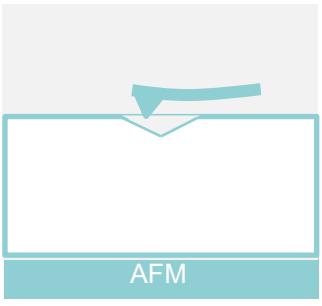

Scale - nano

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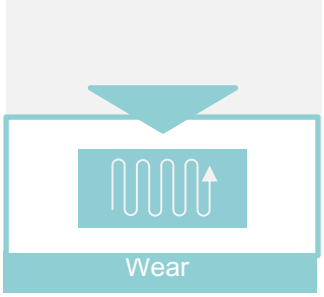
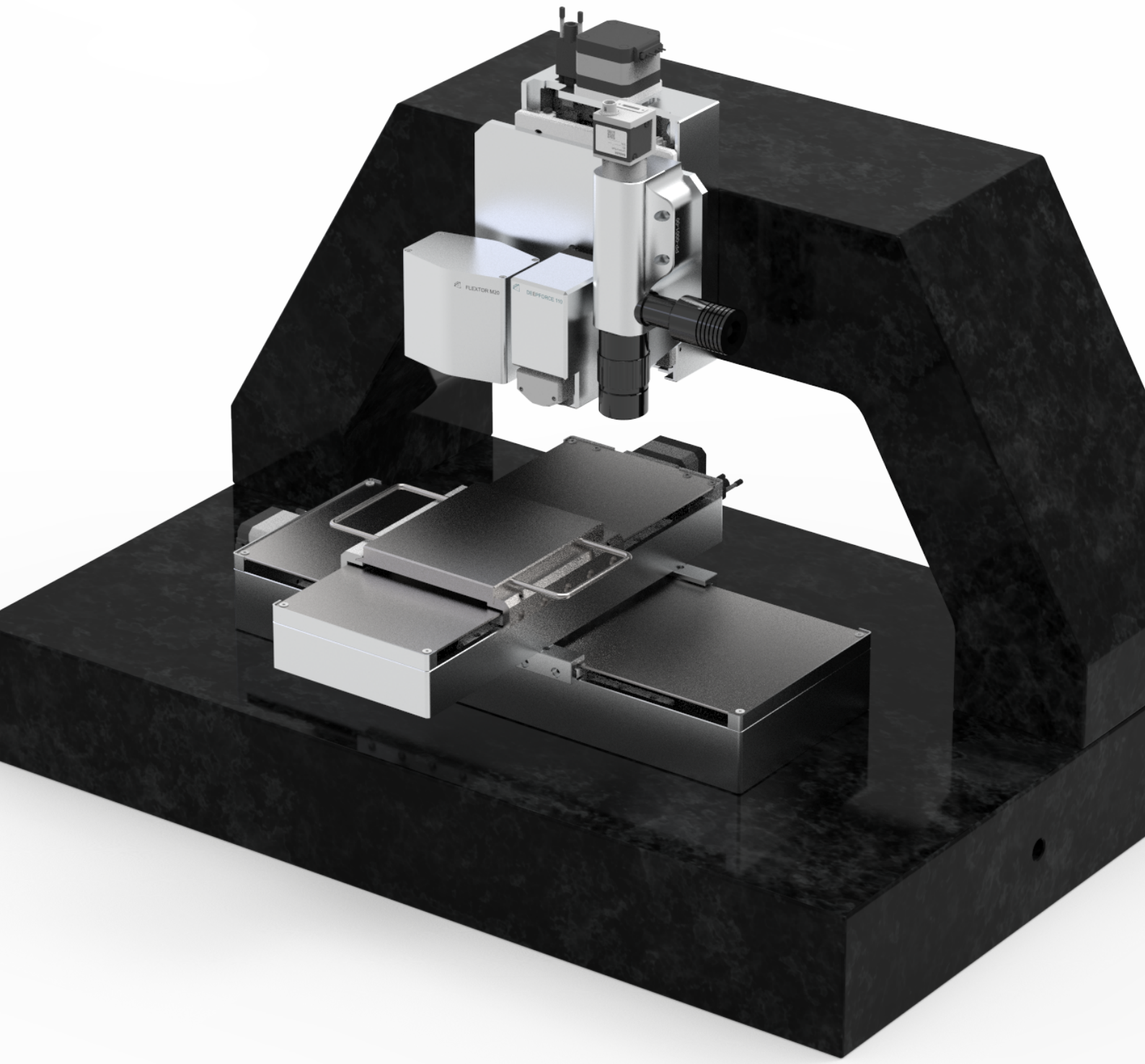


Scale – nano

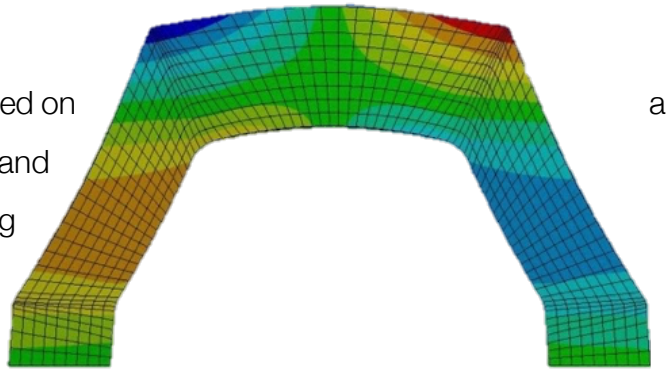
Multi-pass wear tests allow the investigation of nano-wear and micro-wear in a predefined region of interest. This is done using a conventional nano indenter probe and by moving it perpendicular to the sample whilst the contact is either held constant or ramped at a progressive rate. Throughout the test the probe penetration depth and tangential force are acquired.


FLEXTOR M20
DEEPFORCE 110

FoundatiONE™

Integrated multi-role platform for nano and micro mechanical tests

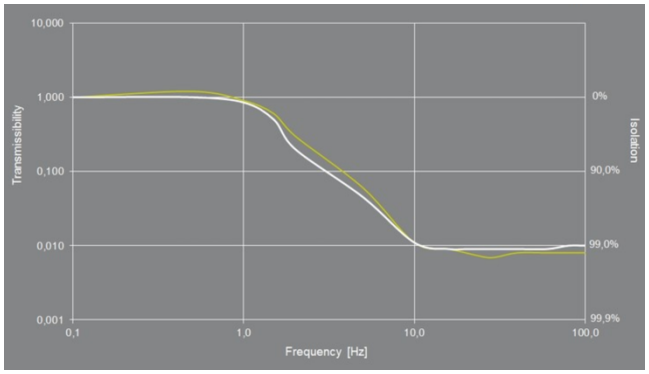
PLATFORM

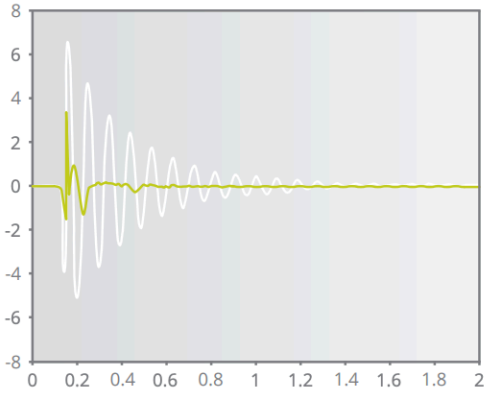


- Metrology grade granite platform mounted on a carbon steel chassis serves as a robust and flexible foundation for mechanical testing and future upgradability.
- Provides load frame stiffness in excess of 10^8 N/m.
- Designed for high rigidity using FMEA analysis and simulation.
- Modular multi-sensor platform capable of integrating multi-scale test transducers, sensors and imaging devices.
- Multi-layer insulated environmental enclosure provides excellent acoustic and thermal isolation.

VIBRATION CONTROL

- High-performance Active vibration isolation built-in to the FoundatiONE platform.
- Low-profile Active vibration control in multiple degrees of freedom.
- Active Isolation over a wide frequency range from 0.5 Hz to 200 Hz. Passive vibration control at frequencies > 200 Hz.
- Real Active Isolation – instantaneous counterforce to compensate vibrations. No air supply needed.
- No natural low frequency resonance. Excellent vibration characteristics at frequencies < 5 Hz.

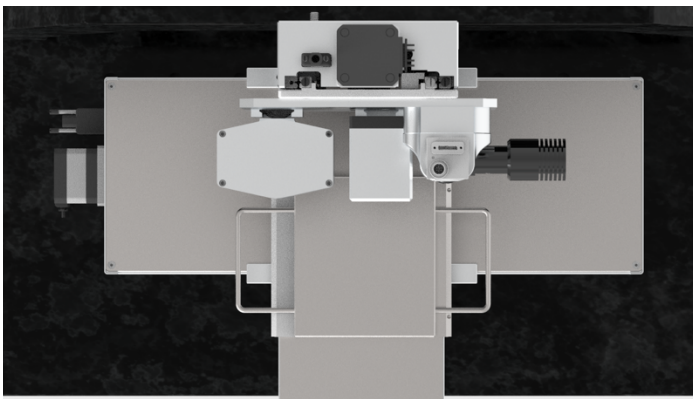




- Sub millisecond response time and low settling time.

MOTION

- Motorized X, Y and Z axis for fast and accurate sample navigation. Motion stages use cross roller guides with zero-backlash ball screws to ensure < 100 nm repeatability and accuracy for minimal tip-optic offset during automated testing.
- Nano scale optical linear encoders on all axes provide nanoscale motion precision.
- EtherCAT motor drives with embedded motion control that integrate well into the fast feedback loop of FoundatiONE's advanced electronics.

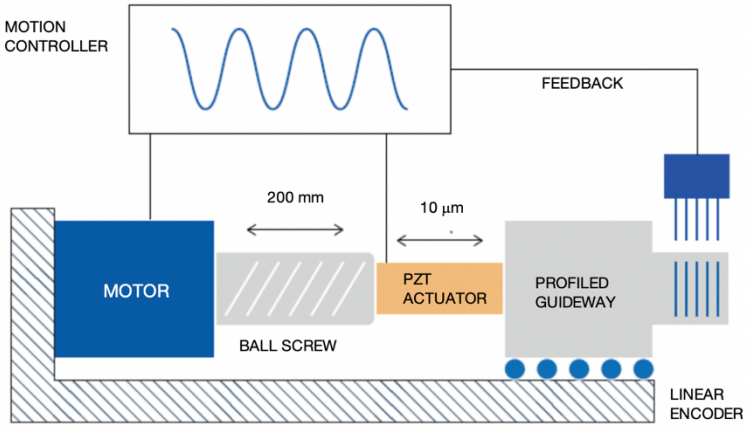


POSITIONING ACCURACY

- Guaranteed positioning accuracy of < 100 nm between the observed region of interest under the optical microscope and the indenter tip.

- Control principle: The motor v` oltage is derived from the control voltage of the actuator. The greater this voltage, the faster the motor runs. When the actuator expands, the motor drives the ball screw in the same direction. In this way, the rough positioning of the ball screw is supplemented by the fine positioning of the actuator. At the same time, the drive screw always automatically moves the actuator near to its zero position.

- A dedicated controller controls both X and Y drives simultaneously and also controls the high-resolution position measuring system. The motion control algorithms compare the actual motion with a calculated trajectory.



CONTROL ELECTRONICS

- Master communication controller and slave DAQ modules with low noise backplane power supply. Master controller supports Ethernet and USB 3.0 for communication with the host PC. It is a three-way bridge between the DAQ modules, FLEXTOR / CROSSBOW Transducers and the DeepSense application suite.

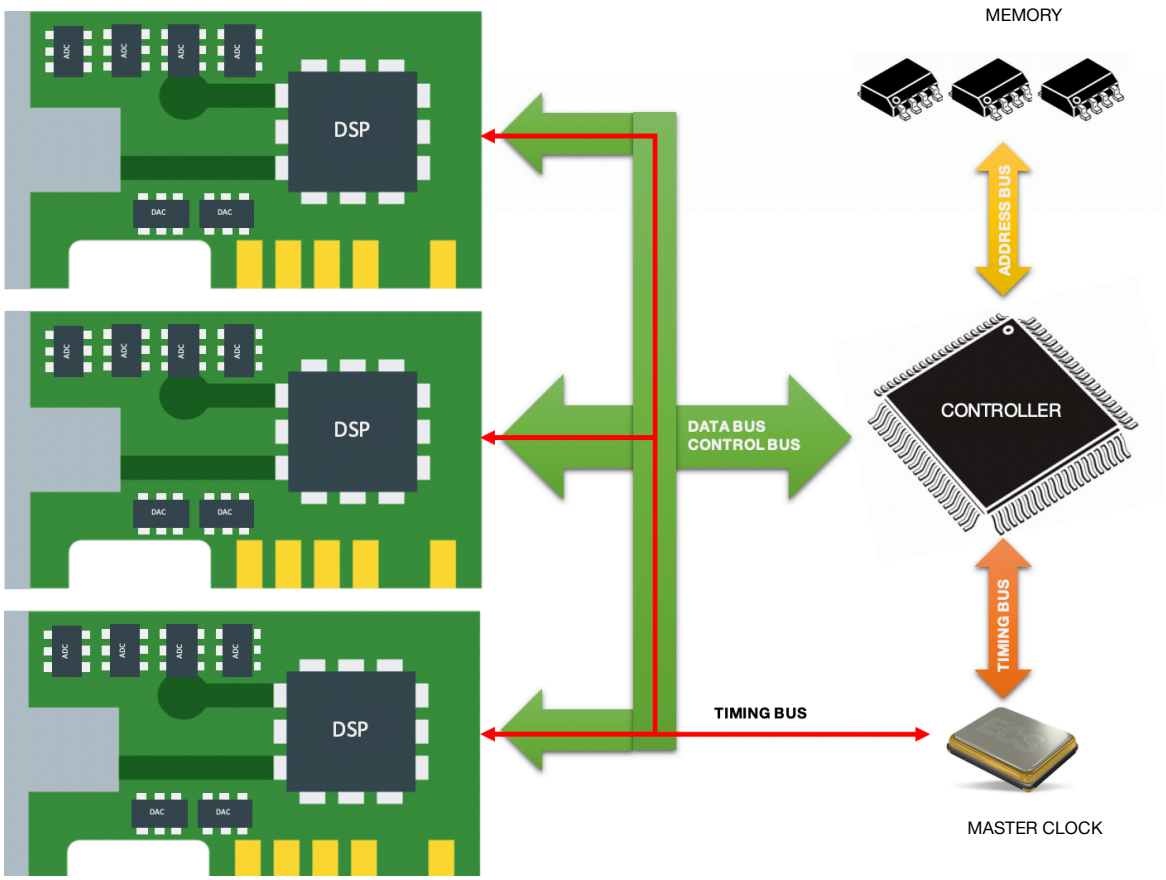
- Each DAQ module includes an array of 32-bit ADCs and 20-bit DACs with a dedicated on-board DSP with FPGA package providing parallel processing and real time acquisition of raw data. Timing pulses of 1MHz are generated from the Master controller. The DAQ modules interact with Master controller using the communication bus with triggered synchronization.

- ADCs can acquire data up to 250 kHz, to limit the effects of noise. Acquisition of raw data during test loops is throttled to 100 kSps. This multi-threaded implementation of control loops provides a maximum feedback loop rate of 100KHz.

- Owing to a high data acquisition rate and innovative memory management, the number of data points per curve is $>10^{5}$*. High accuracy 20-bit DAC output nano size loading steps lead to a maximum of 5000 loading segments for every test profile.

- Industry standard 19” modular rack assembly – IEC 60297-3.

*dependent of Indentation time – sum of load, hold, unload times



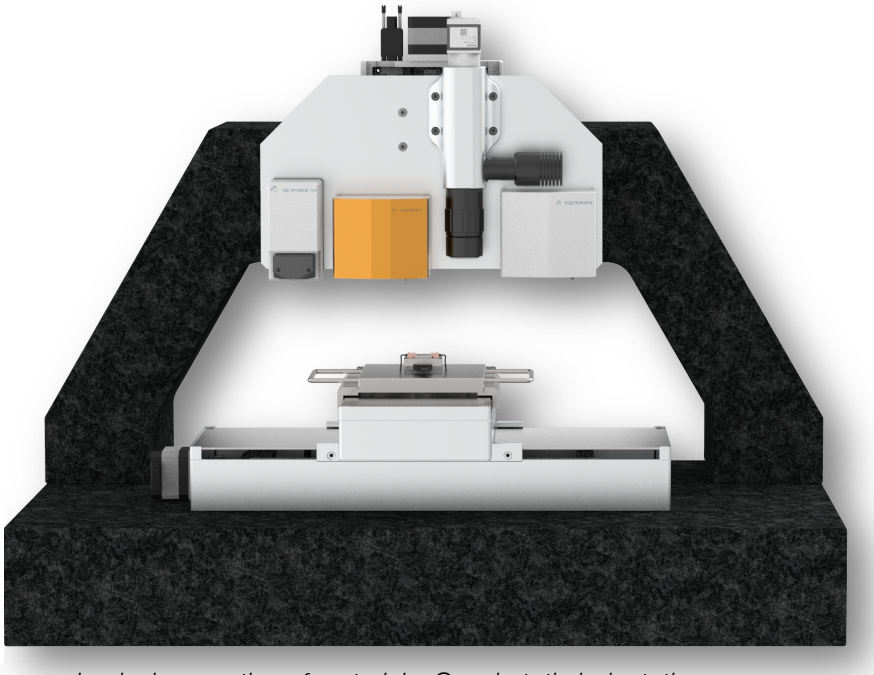
nanoMCB Architecture

MICROSCOPE

- Reflected brightfield microscope for standard and advanced imaging requirements.
- Infinity corrected optical system with Ultra-long working distance Plan-Apochromat objectives for sharp and crisp imaging.
- High-resolution USB 3.0 CMOS sensor for microphotography and imaging provides powerful insights for qualitative analysis.
- CMOS sensor resolution of 2, 3 or 5 megapixels and frame rate of 60 fps.
- Choice of single or multiple magnification optical train.
- 5x, 10x, 20x, 50x, 100x optical magnification.
- Super bright LED illumination with digital intensity controller.
- Fast Auto-focus for sample surface navigation.
- Z-stacking to increase the depth of focus.

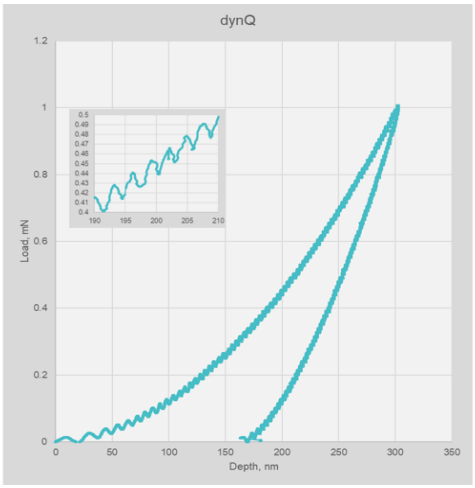
dynQ™

DYNAMIC MECHANICAL ANALYSIS



Indentation is a powerful tool in analysing various mechanical properties of materials. Quasi-static indentation is popular for most analyses, but this technique is ineffective in analysing the viscoelastic properties of materials especially polymers and biomaterials.

With the help of Nanatom's unique control electronics and high-performance transducers, researchers can now dive into the finest details of viscoelastic properties by utilising its powerful dynamic indentation technique using dynQ.



dynQ uses sinusoidal loading, which is superimposed on the quasi-static loading during nanoindentation to uncover time independent mechanical properties like storage modulus, loss modulus, complex modulus, hardness and tan-delta as functions of contact depth, frequency and time.

		dynQ*
Frequency range	Hz	0.1 - 300
Force noise floor	nN	< 25
Displacement noise floor	nm	< 0.2
Max force amplitude	mN	5
Max displacement amplitude	µm	2

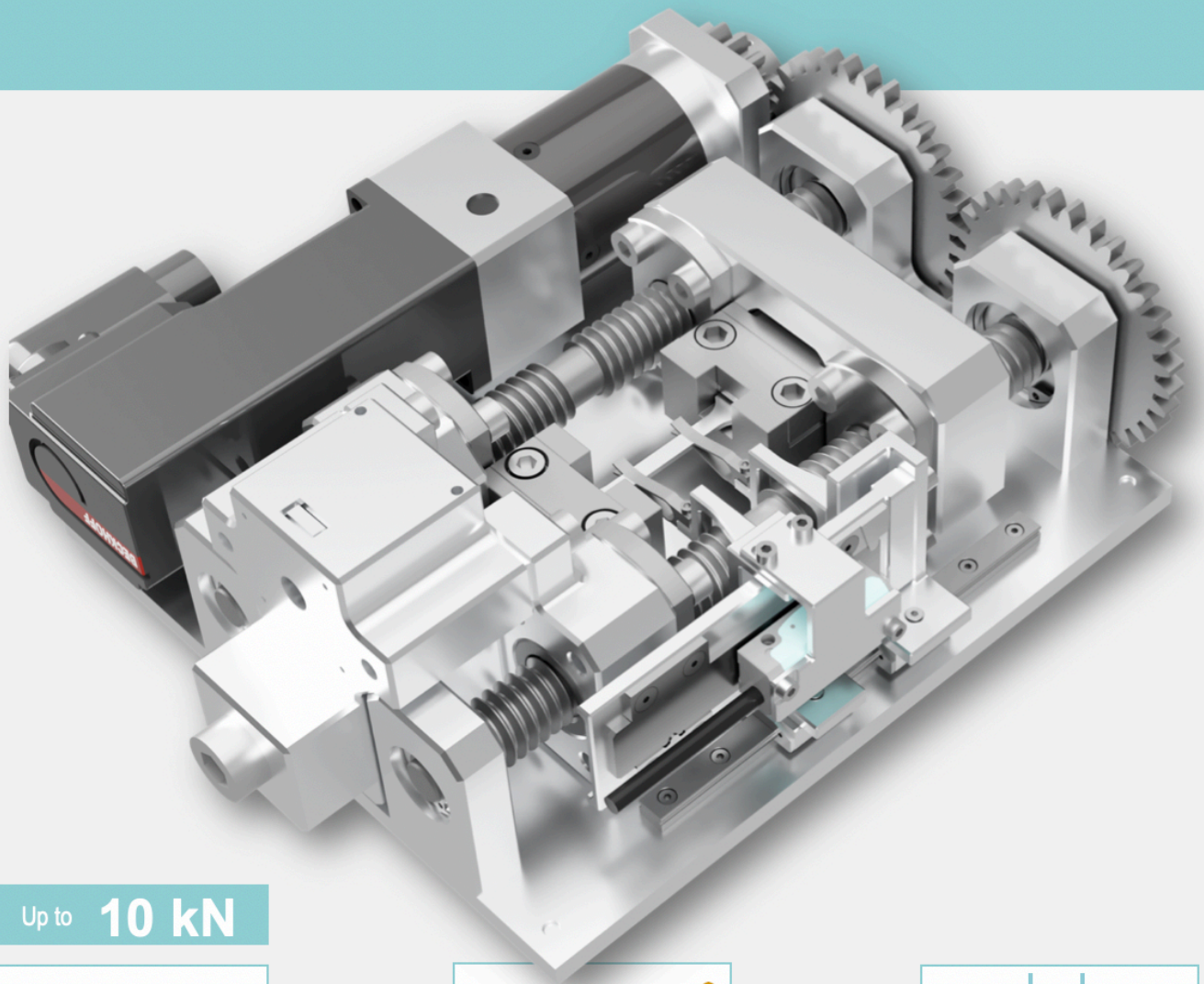
Micro mechanical test platform

In-situ, SEM, XRD, Optical Microscopes

TRAVIX™

'In-situ' Mechanical Test Stage

Using powerful SEM resolution and depth of field capabilities in-situ testing allows analysis of microstructure and study of mechanical properties



Up to **10 kN**

Tension, Compression

Elevated temp testing

3 / 4 Point Bend

Available for SEM, XRD, Optical Microscopes and as a standalone system

APPLICATIONS

Mechanical

- IIT as a tool for material characterisation
- Dependence of plastic energy on the indentation depth and time-dependent plastic deformation
- Coupling statistical indentation and microscopy to evaluate micromechanical properties of materials
- Spring constant calibration by frequency sweep
- Surface roughness of steel balls for tribological testing
- AFM imaging of ball point tip
- Stainless steel metrology indentations
- Dynamic mode AFM of polished sapphire
- Polycarbonate gratings under AFM
- Mechanical Property Distribution by Nanoindentation
- Local work hardening Steel
- Hardness of Complex Coating Systems for Optical Components
- Microhardness test for quality control of LCD spacers

Materials

- Analysis of Tensile stress samples
- Characterisation of airplane wing coating
- Characterization of Laser Beam Welding
- Mehcanical property characterisation of structural ceramics
- Nanoindentation Based Fatigue Analysis of Semiconductor Bridge
- Local plasticc indentation resistance of retained Austentite in bearing steel
- Yield and fracture on PVD and CVD coatings
- Hardness of Complex Coating Systems for Optical Components
- Mechanical characteristics of conformal coatings
- Analysis of Cr/Ni/Cu coatings on plastic substrates
- Mechanical characteristics of anodized coatings

Automotive

- Study of lightweight carbon fibre reinforced polymer for rigid chassis design
- Nanoindentation on wear-resistant DLC coatings applied to engine components
- Scratch Resistance, Recovery Capability, Strength, Roughness
- Young's Modulus, Hardness, Brittle Failure, High Temp Performance of Hard coating
- Coefficient of friction and wear resistance of brake pads and discs
- Local wear/failure and elastic property analysis of tires
- Mechanical strength of coatings at high temperature
- Strength of thermal spray coatings
- Surface morphology of fuel cell components
- Scratch hardness of clear coats and paints
- Measurement of SAM (sprayable acoustic material) coatings for the automotive industry

Aerospace

- Wear evaluation on DLC coating in humidity
- Nanoindentation of Tungsten Carbide hardcoat
- Evaluation of Tribological Coatings for aerospace application
- Measurement Application of Carbon Fiber Reinforced Plastic
- Analysis of Paint Delamination, Wear Resistance, Scratch Recovery
- Fracture toughness of Carbon Nanotube-Epoxy Composites
- Characterisation of Thermal barrier ccatings
- Film delamination, adhesion and performance of Window Hydrophobic Films
- Modulus, Hardness, Yield, Fracture, Adhesion of lead free solders
- Dynamic coefficient of friction and scratch resistance of anti-friction coatings
- Performnce of SiC fiber ceramic matrix composites for engines

NanoTech

- Nanofabrication
- Nanolithography
- Mechanical properties of nanotubes
- AFM force spectroscopy on a polymer blend
- Analysing large structures using AFM stitching
- AFM image of quantum dots
- Nanosphere lithography
- Effects of stress and electron irrdiation on mechanical properties of Silica
- Evaluation of Polymer clay nanocomposites
- Analysis of Polymer cross-linked aerogels
- Investigation of mechanical properties of diatom frustules using nanoindentation
- Nanomechanical Properties of a Bicomponent Epoxy Resin via Blending with Polyaryletherketone
- Nanomechanical response of a micro particle–matrix system for nanoindentation tests
- Obtain z-direction mechanical response in paper based materials using nanoindentation

Pharmaceuticals

- Tablet roughness, fracture toughness and temperature related behaviour
- Film texture measurement
- Surface analysis of carbon
- Creep, stiffness change due to dehydration of contact les hydrogels
- Application of nanoindentation to preformulation studies of APIs
- Measurement of process-dependent material properties of pharmaceutical solids by Nanoindentation
- Material characterisation of poweders using nanoindentation
- Measuring the micro-hardness of tooth enamel in dentistry
- Porosity testing of enamel coatings on equipment used in the chemical and pharmaceutical industries
- Detection of hairline cracks in bearings for medical devices

Semiconductors

- Nanoindentation of GaSe thin films
- Nano surface characterisation
- Bulk micro defect analysis
- Compund material characterisation
- Thin film thickness measurement
- Electrical characterisation of dielectrics and interfaces
- Characterisation of 3D structures
- SI wafer mechanical property testing
- OLED sub-pixel characterisation
- Nanoindentation on intermediate layers in thin foils
- Cyclic nanoindentation of semiconductor and metal thin films
- Topography of solar cell layers
- Screw dislocations in GaN
- Dynamic force measurement on silicon wafer
- Growth morphology analysis of silicon carbide thin film
- MEMS nanoindentation
- Nanoscratch of hard disk drives
- Mechanical analysis of conductive patterms
- Determining mechanical properties of thin CuSn6 foils
- Material analysis of solder bumps in the Integrated Circuit (IC) packaging industry

Bio Medical

- Effect of solvent on polymers - Nylon, Peek, Epoxy
- Nanoindentation of bone
- Nanoindentation of soft biological materials
- Coating on Orthopaedic substrates
- Characterisation and evaluation of dental materials
- Evaluation of shape memory alloys
- Evaluation of cartilage regeneration
- Study of time dependent response of Hydrogels
- Creep and elastic study of cornea
- Adhesion pull-force test for gels
- Study of cell tension, matrix mechanics and cancer development
- Nanoindentation and corrosion studies of TiN thin films for bio-medical application
- Single cell force spectroscopy
- Dynamic mode AFM imaging of bacteria
- Force mapping of living cultured cells
- Imaging DNA
- Creep and relaxation of PMMA coatings
- Nanoindentation to characterise the hardness of coatings on weight-bearing medical implants

SYLLABUS

Machines suitable for the Academic Syllabus/Research

- UG, Mechanical Engineering
- UG, Civil Engineering
- UG, Metallurgical and Materials Engineering
- PG, Mechanical Engineering
- PG, Metallurgical and Materials Engineering
- PG, Civil Engineering
- Projects/Research

UG, Mechanical Engineering

1. Semester 3: Theory and Lab

a. **Subject 1:** Mechanics of Solids/Mechanics of Materials/Strength of Materials
Topics: Mechanics of Rigid and Deformable Bodies
b. Subject 2: Material Science & Metallurgy
Topics: Material Characteristics, Grain Size and Structure Measurement, Heat Treatment (IN-SITU studies can be done)

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.

IN-SITU tests can be done for metallurgical studies.

Material (Sample): Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point), Effect of Alloying elements and heat treatment on properties of steels.
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth, Surface mapping of single and multi layer materials, Effect of Alloying elements and heat treatment on properties of steels.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

2. Semester 4:

a. **Subject: Mechanical Measurement & Metrology**
Topics: Surface characteristics, Surface roughness, Metrology of surface finish

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform experiments of three different materials.
Material (Sample): Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties):
Surface finish, Surface Roughness (RA)
Equipment used: FoundatiONE AFM

3. Semester 5:

a. Subject: Design Of Machine Elements
Topics: Metallurgy of materials

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform experiments of three different materials.
Material (Sample): Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)Equipment used: TRAVIX tensile compression bending

Test parameters 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth, Surface mapping of single and multi layer materials, Equipment used: FoundatiONE micro and nano instrumented indentation equipment

4. Semester 7:

a. Subject 1: Metal Forming Analysis
Topics: Material Behaviour of Extruded, formed, forged, rolled, sheet metal components.

b. Subject 2: Applied Mechanics of Solids, Theory of elasticity, Theory of Plasticity
Topics: To predict the behaviour of a solid that is subjected to mechanical loading.

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform experiments of three different materials.
Material (Sample): Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point), Effect of Alloying elements and heat treatment on properties of above mentioned materials.
Equipment used: TRAVIX tensile compression bending

Test parameters 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength, Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth, Effect of Alloying elements and heat treatment on properties of steels.

Equipment used: FoundatiONE micro and nano instrumented indentation equipment

UG, Civil Engineering

1. Semester 3: Theory and Lab

a. Subject: Mechanics of Materials/Strength of Materials
Topics: Mechanics of Rigid and Deformable Bodies
Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

2. Semester 7: Theory and Lab

a. Subject: Advanced Structural Analysis
Topics: Mechanics of Rigid and Deformable Bodies
Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

UG, Metallurgical and Materials Engineering

1. Semester 3: Theory and Lab
   a. Subject 1: Mechanics of Materials
   Topics: Mechanics of Rigid and Deformable Bodies
2. b. Subject 2: Physical Metallurgy
   Topic: To understand the crystal structures, crystallographic planes, directions, and voids in metallic materials, high temperature deformation
3. c. Subject 3: Polymer Science and Technology
   d. Subject 4: Testing of materials

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

2. Semester 4: Theory and Lab

a. Subject 1: X-ray Diffraction & Electron Microscopy
Topic: To be able to appreciate the importance of XRD and electron microscopy in materials characterization (SEM, TEM, EPMA, FIM, STM)

b. Subject 2: Instrumental Methods of Analysis
Topic: Acquire knowledge of the basic principles of all instrumentation techniques
Gain knowledge on sample preparation and calibration methods for different analysis techniques
Study reverse engineering of products, including metals, polymers, ceramics, composite, and biomedical applications

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

3. Semester 5: Theory and Lab

a. Subject 1: Heat Treatment
Topic: Heat treatment of steels, cast irons and aluminium alloys

b. Subject 2: Physical Metallurgy Laboratory
Topic: Operation of optical microscope and identify the microstructure of ferrous and Non-ferrous sample

c. Subject 3: Powder Metallurgy and Joining of Metals

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

4. Semester 6: Theory and Lab

a. Subject: Ceramics Engineering
Topic: Basics of load bearing properties of various engineering ceramics and correlate them with their microstructure
Knowledge about the processing/manufacturing of various engineering ceramics.

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

5. Semester 8: Theory and Lab

a. Subject 1: Metal Processing Laboratory
Topic: Determine compressibility curve, porosity, tensile strength, hardness and microstructure before and after sintering
Testing of welded specimen and measure mechanical properties

b. Subject 2: Science and Technology of Nanomaterials
Topic: Development of fundamental understanding of the unique properties of nanoscale materials
Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

PG, Mechanical Engineering

Subjects:

1. Metal Processing Laboratory
Topic: Determine compressibility curve, porosity, tensile strength, hardness and microstructure before and after sintering
Testing of welded specimen and measure mechanical properties
2. Metrology & Instrumentation
Topic: Surface finish terminology and measurement
3. Technology of Composite Materials
Topic: Types and classification of typical composite materials. Processing of Polymer Matrix, Metal Matrix and Ceramic Matrix Composite Materials
4. Material Joining Processes
Topic: Classification and characteristics of Welding, Physics and Metallurgy of Welding
5. Micro Electro Mechanical Systems (MEMS)
6. Processing of plastics and composites
7. Destructive Testing
8. Nanotechnology
9. Materials Selection In Mechanical Design
10. Design & Manufacturing
11. Mechanical & Electrical Properties of Materials
12. Smart Structures and Materials

13. Mechanical Behavior of Engineering Materials
14. Precision Engineering Lab

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

PG, Metallurgical and Materials Engineering

Subjects:

1. Materials Characterization Laboratory
2. Advances in Iron Making
3. Experimental Techniques to Metallurgy
4. Process Metallurgy Lab
5. Advanced Welding Technology
6. Corrosion Engineering
7. Plastics Engineering
8. Ceramics Engineering
9. Steels & Their Heat Treatment
10. Mechanical Behaviour & Design of Materials
11. Materials Engineering Lab
12. Composite Materials
13. High Temperature Materials
14. Fracture Mechanics
15. Surface Engineering
16. Science and Technology of Nanomaterials
17. Non-Equilibrium Materials and Processing
18. Advanced Polymeric Materials and Technology
19. Synthesis Techniques for Nanomaterials
20. Carbon Nano Structures & Applications
21. Nanocomposites
22. Nano Biotechnology
23. Microstructure & Mechanical properties of Nano-structures

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.

Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

PG, Civil Engineering

Subjects:

1. Basic Geomechanics
2. Transportation Engineering Lab
3. Pavement Materials
4. Construction Material Lab
5. Advanced Concrete Technology

Experiment: Test, characterise and post processing of below mentioned materials and extract the properties mentioned below. Individual students should perform at least three different experiments of three different materials.
Material (Sample): Concrete, Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.

Test parameters (Material Properties) 1:
Stress, Strain, Yield Strength/Yield Limit, Ultimate strength (UTS), Shear Strength, Flexural Bending (3 Point and 4 Point)
Equipment used: TRAVIX tensile compression bending

Test parameters (Material Properties) 2:
Micro Hardness (Brinell/Vicker/Rockwell hardness), Nano Hardness, Yield Strength,Young's Modulus, Stiffness, Reduced Modulus, Maximum indentation depth.
Equipment used: FoundatiONE micro and nano instrumented indentation equipment

Projects/Research

Verticals:

1. Mechanical
   Topics: Structural dynamics, drive and transmission, power output
   Analysis of Dissimilar Metal Welding of Aluminium and Stainless Steel
   Microindentation methods as an adequate tool for mechanical and structural characterization of biodegradable materials
   Microindentation of titanium: Dependence of plastic energy on the indentation depth and time-dependent plastic deformation

2. Materials:
   Smart materials, sandwich structures, coatings, alloys, metal matrix composites, polymers.
   Mechanical behavior of metallic glasses at the viscous-brittle transition

3. Automotive:
   Study of lightweight carbon fibre reinforced polymer for rigid chassis design of military vehicle
   Passenger safety

4. Aerospace:

5. Civil:
   Coupling statistical indentation and microscopy to evaluate micromechanical properties of materials: Application to viscoelastic behavior of irradiated mortars
   Utilization of micro-indentation technique to determine the micromechanical properties of ITZ in cementitious materials

6. Nano Science:
   Graphene–pure sulfur sandwich structure for ultrafast, long-life lithium-sulfur batteries
   Design, fabrication and electrochemical performance of nanostructured carbon based materials for high-energy lithium–sulfur batteries

7. Electrical:
   Electrical motors, copper alloys, aluminium alloys, power transmission lines,

8. Electronics:
   Bonding wire characterization using automatic deformability measurement

9. **Semiconductors:**
Microindentation studies of Hg0.7Cd0.3Te/CdTe compound semiconductor alloy Silicon Wafer
Phase transformation and residual stress probed by Raman spectroscopy in diamond-turned single crystal silicon

10. **Bio Medical:**
Application of responsive polymers in implantable medical devices and biosensors
Composite coatings for implants and tissue engineering scaffolds
Mechanical Properties of the Human Elbow Bones Measured by Nanoindentation and Microindentation
The tooth: An analogue for biomimetic materials design and processing

11. **Physics:**
Characterization of optical coatings for lenses used in an optical microscope.

Course/SEM	Material	Subject	Type of Tests	Testing Equipment
UG Mechanical - SEM 3	Steels, Aluminium alloys, polymers, plastics, composites, ceramics, nano coatings, carbon tubes, graphene, titanium alloys.	1. Mechanics of Materials/ Strength of Materials 2. Material Science & Metallurgy	Tensile, Compression, Yield Limit, Young's Modulus, UTS, Flexural Bending, Effect of Alloying elements on steels, plastics, aluminium Grain Structure, Size, Heat Treatment (IN-SITU studies can be done)	TRAVIX Tensile, Compression, Bending
			Micro, Nano Vickers, Rockwell, Brinell, Max Indentaition Depth, Surface Mapping,	FoundatiONE micro and nano instrumented indentation
SEM 4	SS 304, Al 6061, C45 MS, Delrin, UHMWPE, Coatings	Mechanical Measurement & Metrology	Surface finish, Surface Roughness (RA)	FoundatiONE AFM

SEM 5		Design Of Machine Elements	Tensile, Compression, Bending	TRAVIX Tensile, Compression, Bending
SEM 7		1. Metal Forming Analysis 2. Applied Mechanics of Solids, Theory of elasticity, Theory of Plasticity	Tensile, Compression, Bending	TRAVIX Tensile, Compression, Bending
			Micro, Nano Vickers, Rockwell, Brinell, Max Indentaition Depth, Surface Mapping,	FoundatiONE micro and nano instrumented indentation, AFM

For students

1: Students who are interested in experimentation connecting to the text books will have more advantages
2: Students can develop new materials and products
3: Students can develop new material research and enrol for Mtech and PHD programs

For Faculties:

1: It helps faculties in doing the research projects by involving respective students and gain the industry interest towards institution
2: They can attract project funding

For MSME centric instituions:

1: MSME industries who cannot afford high end systems can come and utilize this facility centrally.
2: Small scale industries can develop new alloys, materiel, composites for various applications
3: Students who are enrolling to the institution can get placed in material research industries/ instituions.
4: Students can become a better testing engineers in the country who really can contribute towards testing research of any institutes.

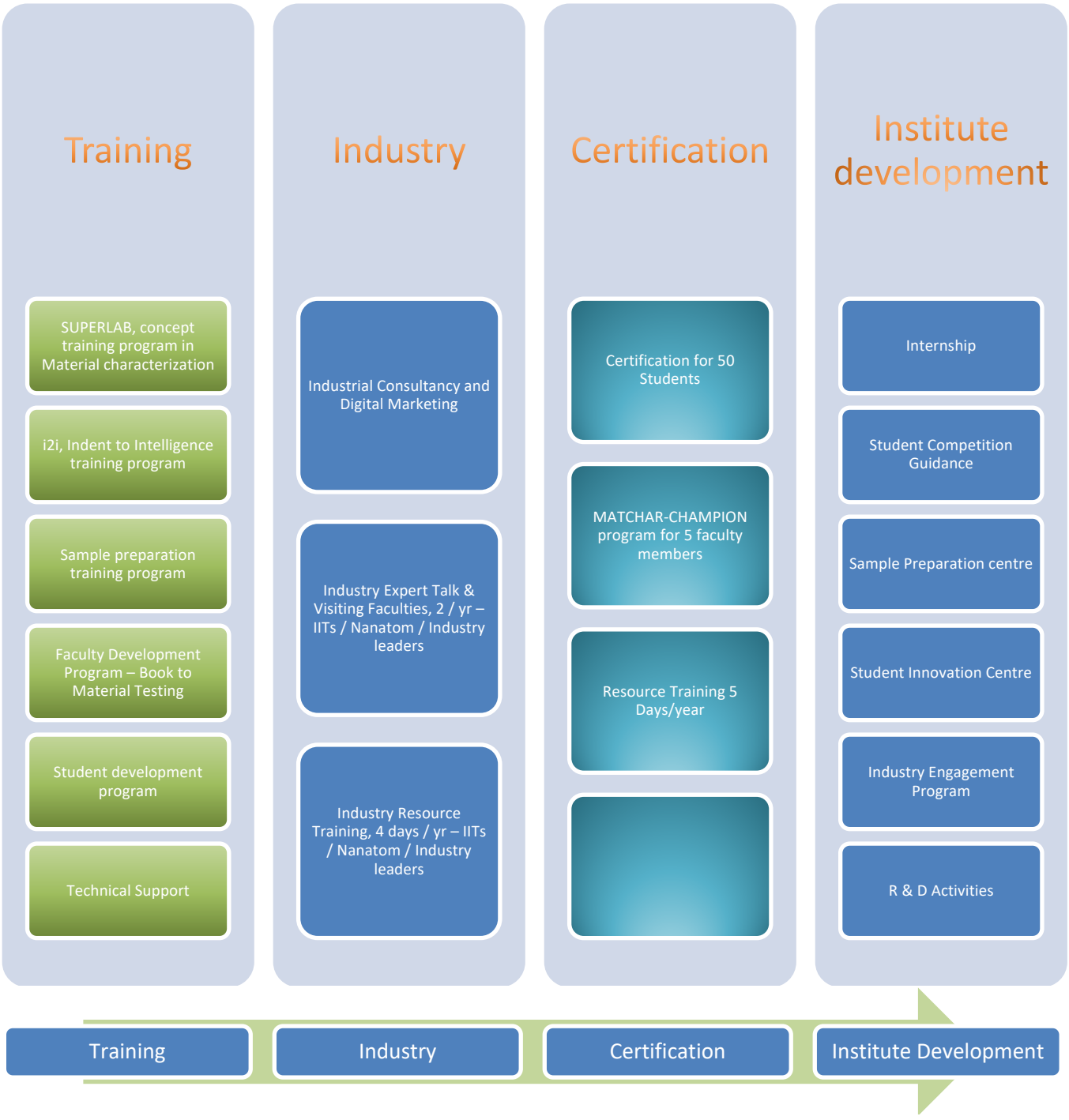
VALUE ADD

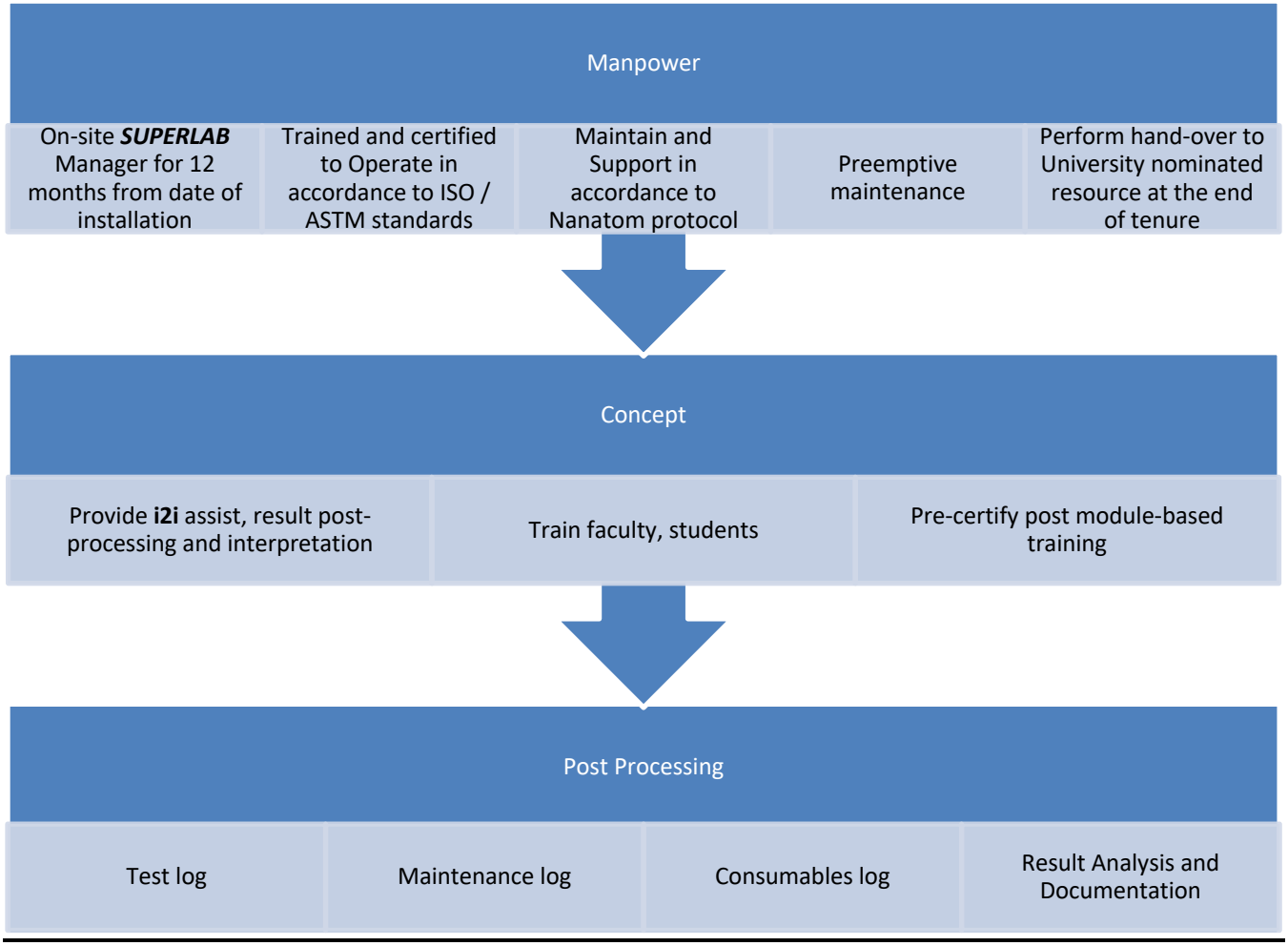
For DRDO :

1: Indegenious material development is becoming a key thrust area where DRDO engineers can really utilize the technology.
2: Material designing in almost all DRDO are happening and material testing is the key area

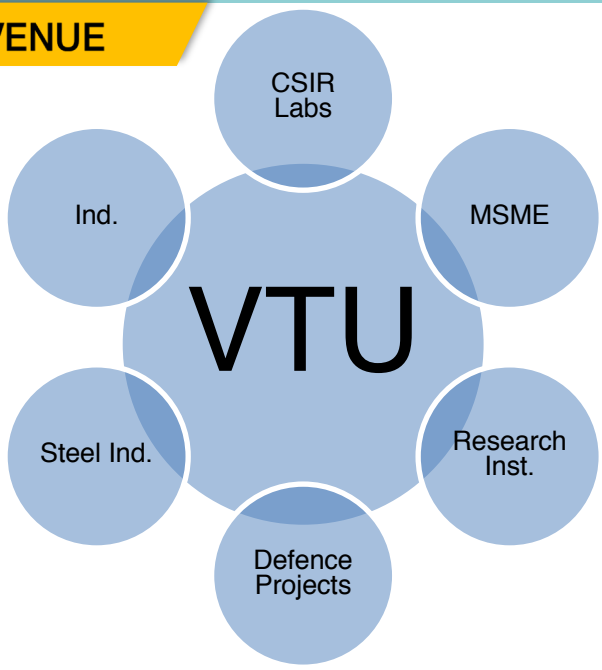
Job Benefits:

1: MSME Testing facility
2: Material Research laboratories




Manpower
On-site SUPERLAB Manager for 12 months from date of installation
Trained and certified to Operate in accordance to ISO / ASTM standards
Maintain and Support in accordance to Nanatom protocol
Preemptive maintenance
Perform hand-over to University nominated resource at the end of tenure
Concept
Provide i2i assist, result post-processing and interpretation
Train faculty, students
Pre-certify post module-based training
Post Processing
Test log
Maintenance log
Consumables log
Result Analysis and Documentation

REVENUE



Institutes	•Create awareness in nearby institutes to come and testing •Invite and conduct regular FDP •Conduct Regular Training programs
MSME	•Create awareness in nearby MSME •Show the capabilities of your testing labs •Get the testing projects
DRDO	•Create awareness in nearby DRDO •Show the capabilities •Get the Consultancy projects
Training	

- Access to the test facility where the Instrumented Indentation System is housed will be provided to users (within VTU and Industry in the vicinity) by booking slots by email or phone in advance for testing samples.
- Prospective users will be given guidelines for sample preparation. Results will be emailed immediately after the test is conducted. A test log will be maintained, and all tests will be documented as a standard operating procedure.
- The test logs can be analyzed annually for an impact study.

ACTIVITY

Activities and Outcome: Institute – Industry development program

Contribution from Nanatom

Year 1

- 1 Week training on testing different samples and do the post processing analysis
- Expert talk from Senior experts from NANATOM introduction to worldwide best practices
- Continuous support and guidance will be provided by the Nanatom team for the project

Year 2

- 2 Week Advanced Technology training on advanced engineering samples testing
- Training from Senior experts from Nanatom
- Workshop from Senior experts from selected Industry for orientation on standards and expectations
- Continuous support and guidance will be provided by the Nanatom team for the project

Activities from VTU

Year 1

- Make detailed plan for research and development
- Familiarize the researchers with the industry requirements and the path in which the same can be attained.
- Train the researchers on Mechanical testing and Characterization
- Literature study and implement sample problems for understanding

Year 2

- Understand qualification and certification standards and protocols
- Preparation and Testing of samples
- Design of experiments

Year 1

OUTCOME

- Familiarize and educate the researchers on the stringent requirements in industry sector
- Train the researchers on industrial requirements and on how to attain them by using the best technology platform
- Trained manpower is ensured at end of year 1

Year 2

- Industry Consultancy
- Marketing and advertising programs
- Workshops/seminars

INFRA

Specs	System Details	Remarks
Data aquisition and Analysis	Computer allocated along with the system	Default
High End post processing analysis system by sending the test results for further analysis	Need to buy HPC Computing facility additionally	

OUTLINE

3-Yr. PROGRAM OUTLINE

#	Description
1	CoE on Interdisciplinary Material Testing – A CIF Facility contains • Mechanical testing • Nanoscience material testing • Automotive material Testing • Bio Samples / Dental testing • Tribology Materials testing • Ceramic Testing • Electrical Materials Testing – Cables, Wires, Insulation, etc. • Semiconductor testing
2	Faculty, Research Scholars and Student (B.Tech & M.Tech) Development Program • 50 Students - Student Certification in 3 Years in total • 5 Faculties - Train the Trainer Program Per Year
3	Institute Development Program • Research & Development initiatives • Student Innovation Center • Student Competition guidance • Resource Training 5 Days/year • Internship Support
4	Industry Engagement Program • Industry Expert Talk & Visiting Faculties (2 per Year) – Industry/IITs/Nanatom • Industry Resource Training 4 Days/year - Industry/IITs/Nanatom
	Implementation Plan • Year 1 – Deployment of NANATOM Products • Year 2 – Incubation Support, Internship Support (2 nos), Domain Specific Training • Year 3 – Development of Incubation and Startups, consulting activities, Marketing activities

FoundatiONE™ Integrated Nano & Micro Mechanical Test Platform

- Nanatom's nano & micro mechanical test platform FoundatiONE™ is designed to conduct instrumented nano indentation tests with high precision. This unique testing equipment is capable of measuring various characteristics of materials like metals, alloys, ceramics, powder metallurgy materials, thin films in accordance with ISO and ASTM standards.

- FoundatiONE™ delivers precise material characteristics in form of contact area, contact depth, hardness, modulus, relaxation and creep under tight feedback control modes while offering the option of completely-automated and manual test routines.

- DeepSense™ an intuitive and user-friendly software platform provides a feature rich experience in exploiting FoundatiONE's powerful electro-mechanical testing abilities. Combined with high speed data acquisition DeepSense provides powerful analytical abilities.

FoundatiONE™ Configuration – N + T

Part No.	Part	Description	
DP-P02	FoundatiONE™ Platform	Vibration Isolation platform	₹ 0,000
	- *India package*	Multi-sensor upgradeable ○ Upgrade to Micromechanical test ability ○ Multi-sensor ready	
		Mechanical levelling Chassis ○ Rigid metal support frame ○ Engineered to mechanically dampen vibrations	
		Granite platform ○ High rigidity foundation forms the basis for reliable measurements and data acquisition	
		Environmental Enclosure ○ Insulated upright enclosure housing the platform, test stage, electronics and controls all in one compact unit ○ Protects sensitive electronics and sensors from environmental noise ○ 240 V, 50 Hz, Type M - AC Input socket with circuit breaker and fuse protection AC line spike and surge filters	

Part No.	Part	Description	
DP-F02	Flextor™ N30 Nano Force-Displacement Transducer	○ 6-plate force-displacement capacitive transducer enhances reliability, improves resolution and accuracy ○ Electrostatic force actuation and capacitive displacement sensing ○ Max. normal force – 30 mN ○ Max. lateral force – 4 mN ○ Lateral force bit resolution – 50 nN ○ Max. displacement – 25 µm ○ Max. scratch length – 20 µm ○ Scratch speed – 100 nm/s to 3 mm/s ○ Max. surface contact force – 70 µN ○ Piezo controlled flexure for approach, surface scan and perpendicular loading ○ Transducer electronics and mounting hardware ○ SPM low force imaging ○ Micro pillar compression test ○ Micro beam bending test	
DP-F01 +DFNR0103	Flextor™ M20 Micro Force-Displacement Transducer	○ Multi-plate force-displacement capacitive ○ transducer enhances reliability, improves ○ resolution and accuracy ○ Piezo force actuation and capacitive ○ displacement sensing ○ Max. normal force – 20 N ○ Max. displacement – 100 µm ○ Double cantilever flexure for approach, ○ surface scan and perpendicular loading ○ Transducer electronics and mounting ○ hardware ○ Bending of micro-beams and cantilevers ○ LCF of micro-beams and cantilever ○ Fracture toughness	
EC-N02	nanoMCB™ ECU	○ Embedded controller unit with 32-bit ARM® Cortex®-M4F ○ TwinCAT real time motion control with low jitter and multiple sockets ○ Three axis servo motor control with 100 nm position accuracy ○ Digital outputs with switching ON time of 60 µs	
ME-D0201	Motion	○ Ultra-compact DC motors ○ Low rotor inertia ○ High resolution encoder feedback ○ Precision cross roller guides ○ Recirculating ball caged ball-screw rods ○ X axis: 200 mm travel ○ Y axis: 75 mm travel ○ Z axis: 50 mm travel ○ SS sample stage with dove tail mechanism for easy removal, installation and locking	
DFNM0501	Heating stage *Room temp to 450 deg C*	○ Temperature resolution – 0.1 ºC ○ Drift rate during high temp testing – 1 nm/sec	

Part No.	Part	Description	
DP-M01 +DFNS0302	Microscope	○ Infinity corrected optical train ○ 50x ULWD Plan Apochromat objective ○ Brightfield ○ Working distance – 20 mm ○ Field of view – 1200 x 1200 µm ○ Digital imager with 5.0 mega pixel resolution ○ Fiber optic LED illuminator ○ Electronic illuminator intensity controller	
DP-DMA	DeepDynamic *Dynamic Mechanical Analysis Module*	○ DeepDynamic technique for advanced dynamic measurement of materials with viscoelastic properties in the frequency and time domains ○ Test materials for Storage modulus, loss modulus, complex modulus, tan-delta, reduced modulus, young's modulus ○ Force amplitude range from 0.01 µN to 200 µN ○ Displacement amplitude range from 0.1 nm to 5 nm ○ Frequency range from 0.1Hz to 300 Hz ○ Drift compensation for long-term creep tests	
DS-110 +DFNW0101	DeepSense™ *Core* *Topo module*	Navigate ○ Sample tagging, test boundary creation ○ X, Y, Z navigation ○ Live sample view ○ Auto focus for rapid sample surface approach	
		Parameterize ○ Create and edit test parameters ○ Define custom Load functions ○ Choose between Load control and Displacement control feedback loops ○ Automated test macro ○ Surface search and memory ○ Adaptive anti-collision algorithm to keep the indenter from crashing into the sample ○ User-defined data acquisition rates of up to 30 K samples per second	
		Acquire ○ Measure force and displacement as a function of time ○ Indentation cycle - Live plot	
		Analyze ○ Raw data Load-Displacement curve fitting based on Power law and other methods ○ Export analyzed data to PDF, XLSX, HTM, CSV formats ○ 3D, 4D plot for modulus mapping ○ Custom report generation	
		Tools ○ General and M/c connectivity ○ PID calibration ○ Sample height calibration ○ Probe offset calibration ○ Machine diagnostics ○ Configuration settings	
CN-IK1	Indentation Kit	○ Berkovich (2 Nos), Cube corner (1 No), Conical Indenter (2 Nos)	

Part No.	Part	Description	
	Config N Standard	○ Indenter changeover toolkit ○ High-Temperature indenter toolkit with holders and indenters	
CN-CK1	Calibration Kit	○ Fused silica calibration block	
	Config N Standard	○ SS calibration block	
SR-NW1	Warranty	○ 1-year from date of installation	
	Premium Support	○ Online and telephonic support	
		○ 48 hr On-site support – Tier 1 Indian cities ○ 72 hr On-site support – Tier 2 Indian cities	

COMMERCIAL OFFER

Configuration N Price	₹ 0,000
Final Price	₹ 0,000
GST @ 5%*	₹ 0,000
FoundatiONE™ Configuration N, Total Price in INR	**₹ 0,000**

**If customer able to provide exemption certificate to charge 5% GST the same will be applied*

(Rupees XxxXXXXX only)

- Inclusive of prevailing duties and taxes
- Inclusive of shipping and insurance
- Inclusive of delivery and on-site Installation
- Inclusive of 3-day on-site customer training
- Payment Terms – 50% with order, balance again Proforma Invoice at delivery

Standard Terms and Conditions
TC-S01A

1. GENERAL
   For the purpose of this document the term "Seller" or "Nanatom" refers to Nanatom® Technologies Pvt Ltd. and its authorized Sales Partners. The "Buyer" is the party purchasing the equipment and to whom this document is addressed. The "Equipment" refers to the product(s) listed in the document to which these Standard Terms and Conditions are attached. In the event of a conflict, inconsistency or addition not expressly accepted in writing by Seller, the terms and conditions of sale provided herein shall be considered as superseding the conflicting, inconsistent or additional terms stated in the Buyer's purchase order. The acceptance of an order shall supersede all prior communications and constitute a complete and binding contract between the Buyer and Seller.

2. SHIPPING
   The Seller will attempt to fulfil with organized delivery period but the Seller reserves the right to sanction or prorate shipments against all orders whenever, in its decision, an oversold condition exists as to any particular product produced or sold by Seller. In the event of a default by the Buyer, Seller may drop to make further shipments without waiving any of its rights under such order. In, regardless of, Seller chooses to continue to make shipment, its action shall not setup a waiver regarding, or otherwise lessen, Seller's legal remedies with respect to such evasion or any further defaulting.

3. FORCE MAJEURE
   The Seller shall not be liable for delays in delivery or failure to deliver due too directly or indirectly caused by strikes, lockouts, labour difficulties, riots, inability or difficulty in obtaining or procuring supplies, labour or transportation, fires, storms, floods,

earthquakes, explosions, accidents, acts of God, interference by civil or military authorities, whether legal or de facto, acts of the public enemy, war, rebellion, insurrection, sabotage, embargoes, orders given priority by any public authority or any other cause beyond the reasonable control of Seller.

4. PRICES

The prices quoted by Seller in this Quotation are final. Only an order matching the price quoted in this Quotation will be accepted by the Buyer. Any additional equipment, utilities or services required for the installation and operation of the Equipment are not included in this quotation.

5. PAYMENT TERMS

Invoices presented by Nanatom to the Buyer are payable within the due date set forth in the invoice. Any amounts not paid when due will bear interest at a rate of 18% per annum.

6. TAXES

All prices are quoted by Nanatom are inclusive of GST and other local taxes prevailing at the time of drafting the quotation. In the event of any revision to the prevailing tax rates the same shall be paid by the Buyer. If the Buyer is privileged to purchase by paying lower or no taxes, the Buyer needs to inform the Seller prior to raising an invoice and furnish a Tax exemption certificate acceptable to commercial tax authorities.

7. CANCELLATION TERMS

In the event of cancellation of an order by the Buyer for a standard item, the Buyer shall pay to Nanatom, a cancellation or restocking fee as mentioned in Table 1, at the sole discretion of Nanatom. Such events are authorized by prior approval of Nanatom only

Table 1

Days lapsed when cancellation request issued after confirmed shipping date	Cancellation Fee
> 90 Days	25% of Purchase Price
15 - 90 Days	50% of Purchase Price
0 - 15 Days	100% of Purchase Price

8. WARRANTY

The Seller warrants to the Buyer that new equipment will be free of defects in material and workmanship for a period of one year commencing on the date of installation or 90 days from shipping, whichever occurs first. This warranty covers the cost of parts and labour.

The Seller warrants to the Buyer that replacement parts will be new or of equal functional quality and warranted for the remaining portion of the original warranty or 90 days, whichever is longer.

The Seller warrants to the Buyer that software will perform in substantial compliance with the written materials accompanying the software. Seller does not warrant uninterrupted or error-free operation.

Seller's obligation under these warranties is limited to repairing or replacing at Seller's option defective non-expendable parts or software. These services will be performed, at Seller's option, at either Seller's facility or Buyer's business location. For repairs performed at Seller's facility, Buyer must contact Seller in advance for authorization to return equipment and must follow Seller's shipping instructions. Freight charges and shipments to Seller are Buyer's responsibility. Seller will return the equipment to Buyer at Seller's expense. All parts used in making warranty repairs will be new or of equal functional quality.

The warranty obligation of Seller shall not extend to defects that do not impair service or to provide warranty service beyond normal business hours, Monday through Friday (excluding Seller holidays). No claim will be allowed for any defect unless Seller shall have received notice of the defect within 30 days following its discovery by Buyer. Also, no claim will be allowed for equipment damaged in shipment. Within 30 days of Buyer's receipt of equipment, Seller must receive notice of any defect which Buyer could have discovered by prompt inspection.

The exclusions from this warranty include all standalone computer and data storage equipment not manufactured by Seller (such as computers, monitors, printers and printer buffers). Such equipment will carry only the original manufacturer warranty.

The Seller assumes no liability under the above warranties for equipment or system failures resulting from (a) abuse, misuse, modification or mishandling (b) damage due to forces external to the machine including, but not limited to, acts of God, flooding, power surges, power failures, defective electrical work, transportation, foreign equipment/attachments or Buyer-supplied replacement parts or utilities or services such as gas; (c) improper operation or maintenance; or (d) failure to perform preventive maintenance in accordance with Seller's recommendations (including keeping an accurate log of preventive maintenance). In addition, this warranty does not apply if any equipment or part has been modified without the written permission of Seller or if any Seller serial number has been removed or defaced.

No one is authorized to extend or alter these warranties on Seller's behalf without the written authorization of Seller.

9. LIMITED LIABILITY
The Seller shall not be liable for consequential damages, for anticipated or lost profits, incidental, indirect, special or punitive damages, loss of time, loss of use, or other losses, even if advised of the possibility of such damages, incurred by Buyer or any third party in connection with the Equipment or services provided by Seller.

10. APPLICABLE LAWS AND JURISDICTION
The contract created hereby shall be interpreted and construed under the Indian laws under Jurisdiction of Bangalore in the State of Karnataka, if otherwise applicable. The exclusive venue for any disputes arising out of or in connection with such contract shall be in the Jurisdiction of Bangalore in the State of Karnataka.

11. ARBITRATION
Any dispute or difference whatsoever arising between the Buyer and the Seller out of or relating to the construction, meaning, scope operation or effect of this contract or the validity or the breach thereof shall be settled by arbitration in accordance with the Rules of Arbitration of the Indian Council of Arbitration and the award made in pursuance thereof shall be binding on the parties.

ROI Estimation

(MSME / Industries)

Tests per week • Instrumented indentation – Nano / Micro • Scratch – Nano / Micro • Tension / Compression / Bend • AFM	 5 days / week for 40 usable weeks 20 / week 15 / week 15 / week 10 / week Total – 60 / weeks
Chargeable fee to MSME	Rs 1500 / test average
Revenue 40 weeks / annum	Rs (1500 x 60) x 40 = Rs 36,00,000

(Student)

Tests per week • Instrumented indentation – Nano / Micro • Scratch – Nano / Micro • Tension / Compression / Bend • AFM	 5 days / week for 40 usable weeks 20 / week 15 / week 15 / week 10 / week Total – 60 / weeks
Chargeable fee to Student	Rs 500 / test average
Revenue 40 weeks / annum	Rs (500 x 60) x 40 = Rs 30,00,000