Plasma Technologies for Aerospace Application

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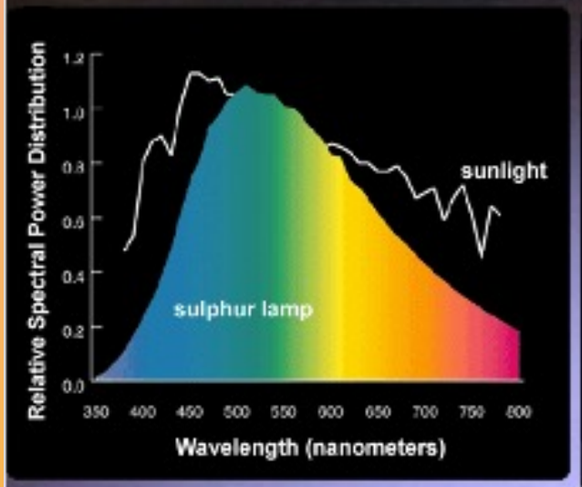
25 Years of FCIPT

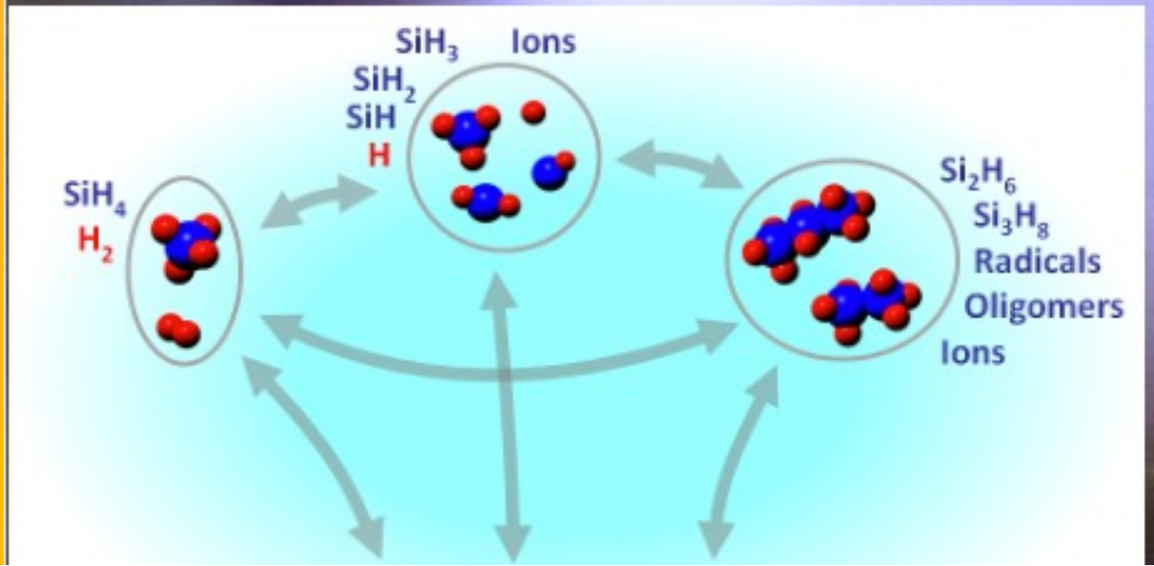
24-25 NOVEMBER 2022
GANDHINAGAR

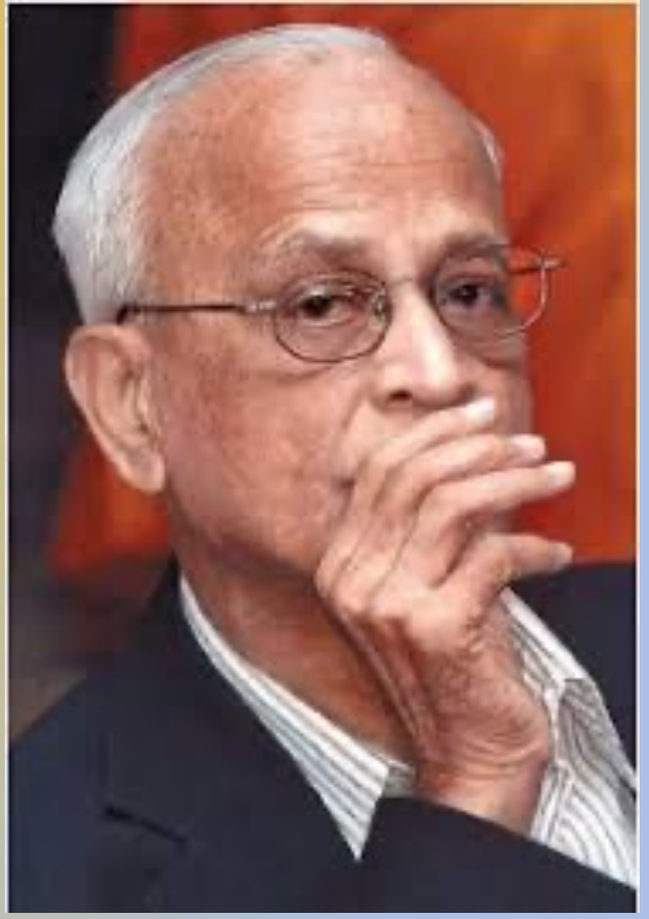


- high chemical reactivity
- microscopic electric fields
- Sheaths
- radiation and particle flux

- Integrates the plasma-material interaction the manufacturing process

- Both the equilibrium and non-equilibrium plasmas can be exploited

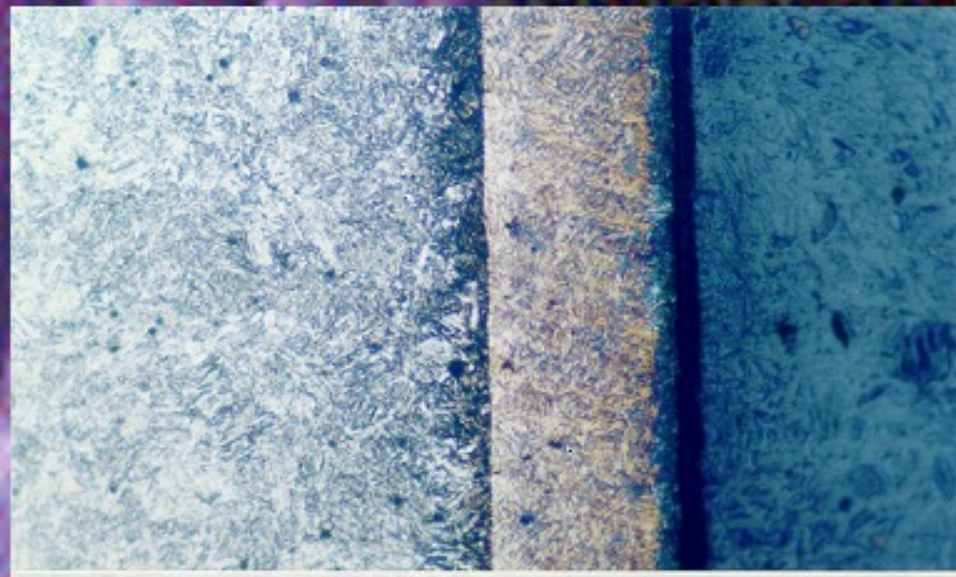




There were no pre-existing models of similar activity in basic research organizations in India. The activity had unique features not encountered in basic research. The necessity for it to be relevant to industry, the fact that it can make or lose money in its commercial exploitation, the contractor-client relationship with industries etc. are some examples

FCIPT is a path breaker in India in converting physics-based research into commercially and societally valuable devices and processes in basic research organizations. Over the years, we have learned how to use the plasma environment to do various useful things

PLASMA NITRIDING OF INDUSTRIAL-SCALE COMPONENTS



Etchant : Ferric Chloride Mag : 125 X

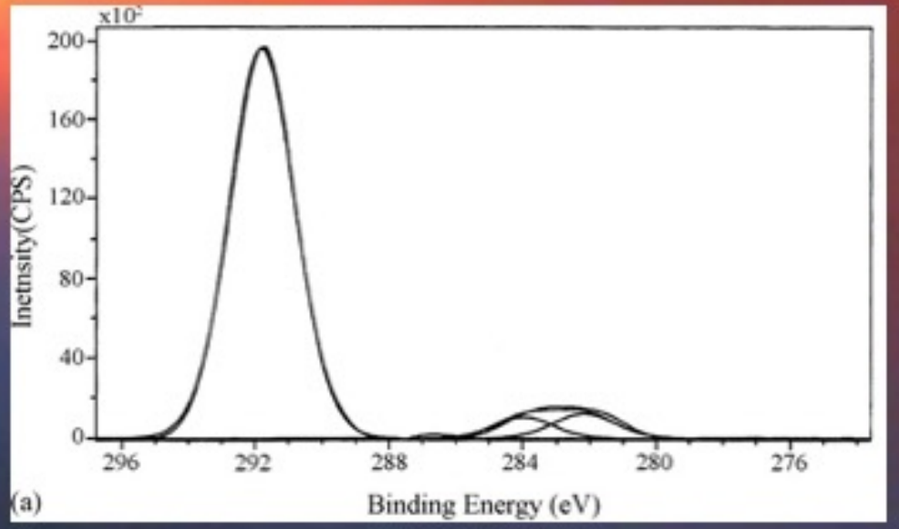
PLASMA POLYMERISED DIFFUSION BARRIER ANTI-TARNISH COATINGS

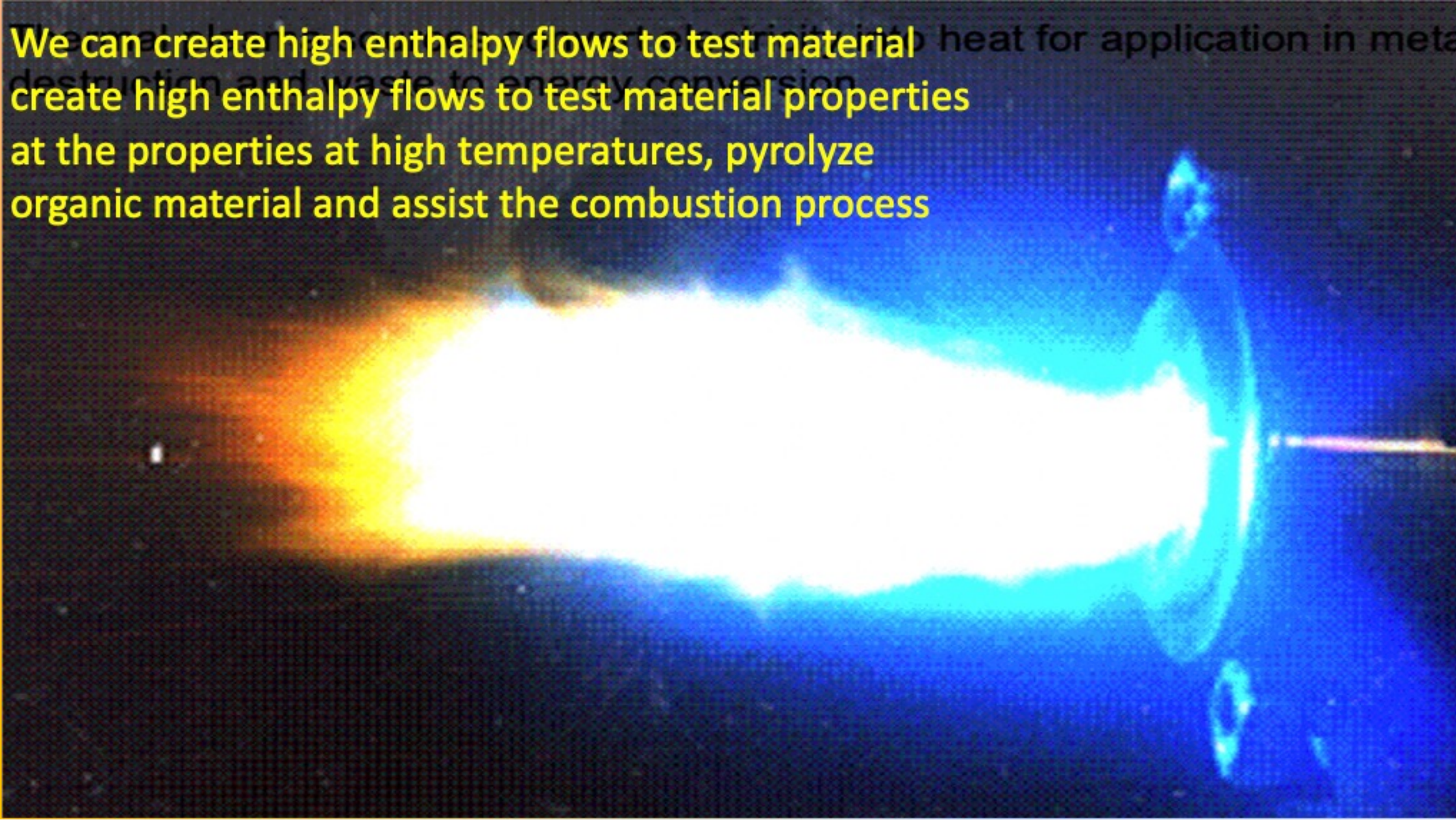
PLASMA JET CVD

Rubber seals for fast breeder reactor

Contact angle =165° spherical drops

Nanostructured Superhydrophobic Coating was synthesized from CF_4 produced by pyrolyzing waste Teflon-Silicon carbide and Teflon like Coatings




We can create high enthalpy flows to test material
create high enthalpy flows to test material properties
at the properties at high temperatures, pyrolyze
organic material and assist the combustion process

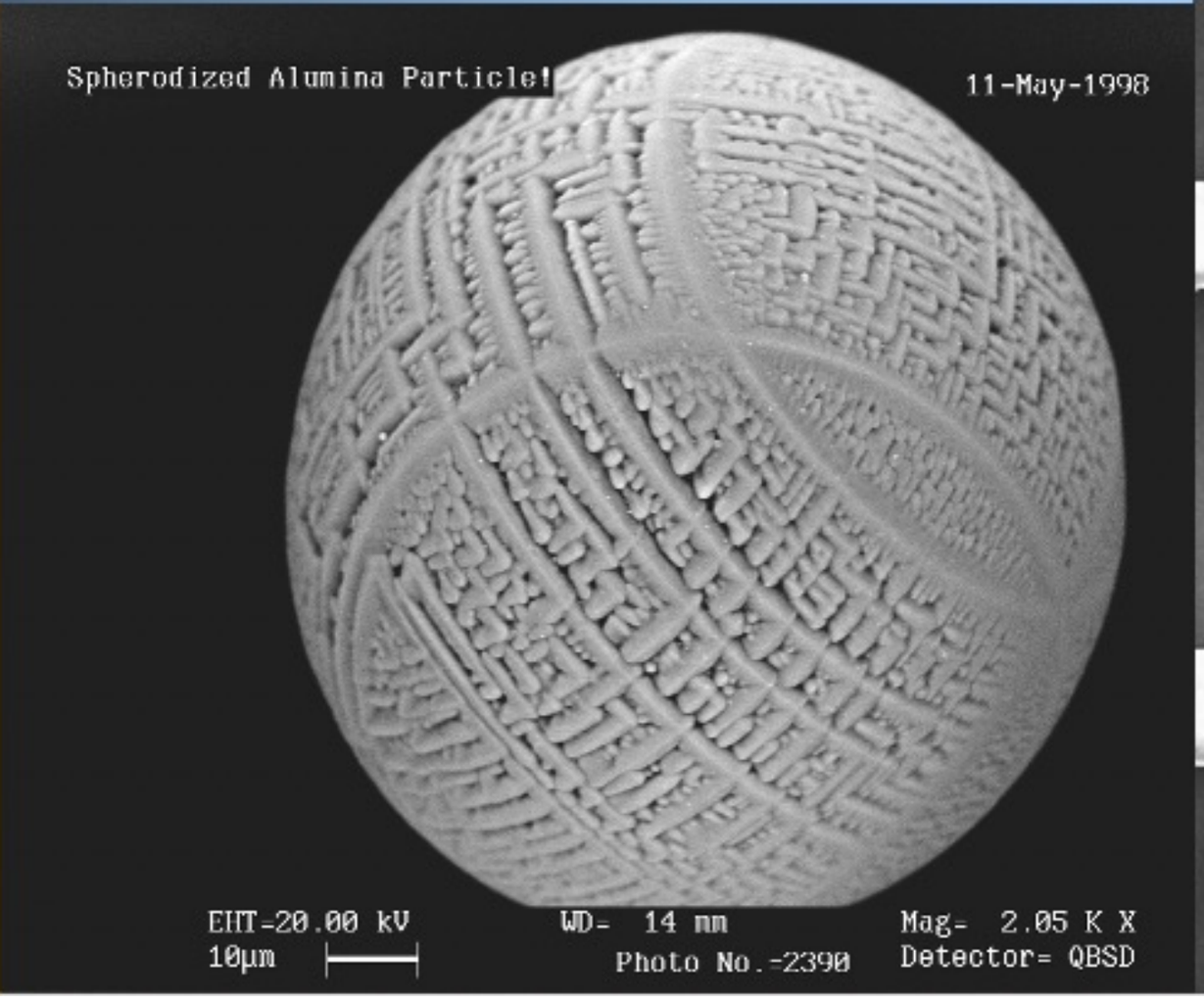
Plasma treated brass valves moulded with rubber shows improved adhesion: Replaces chemical etching with hazardous materials

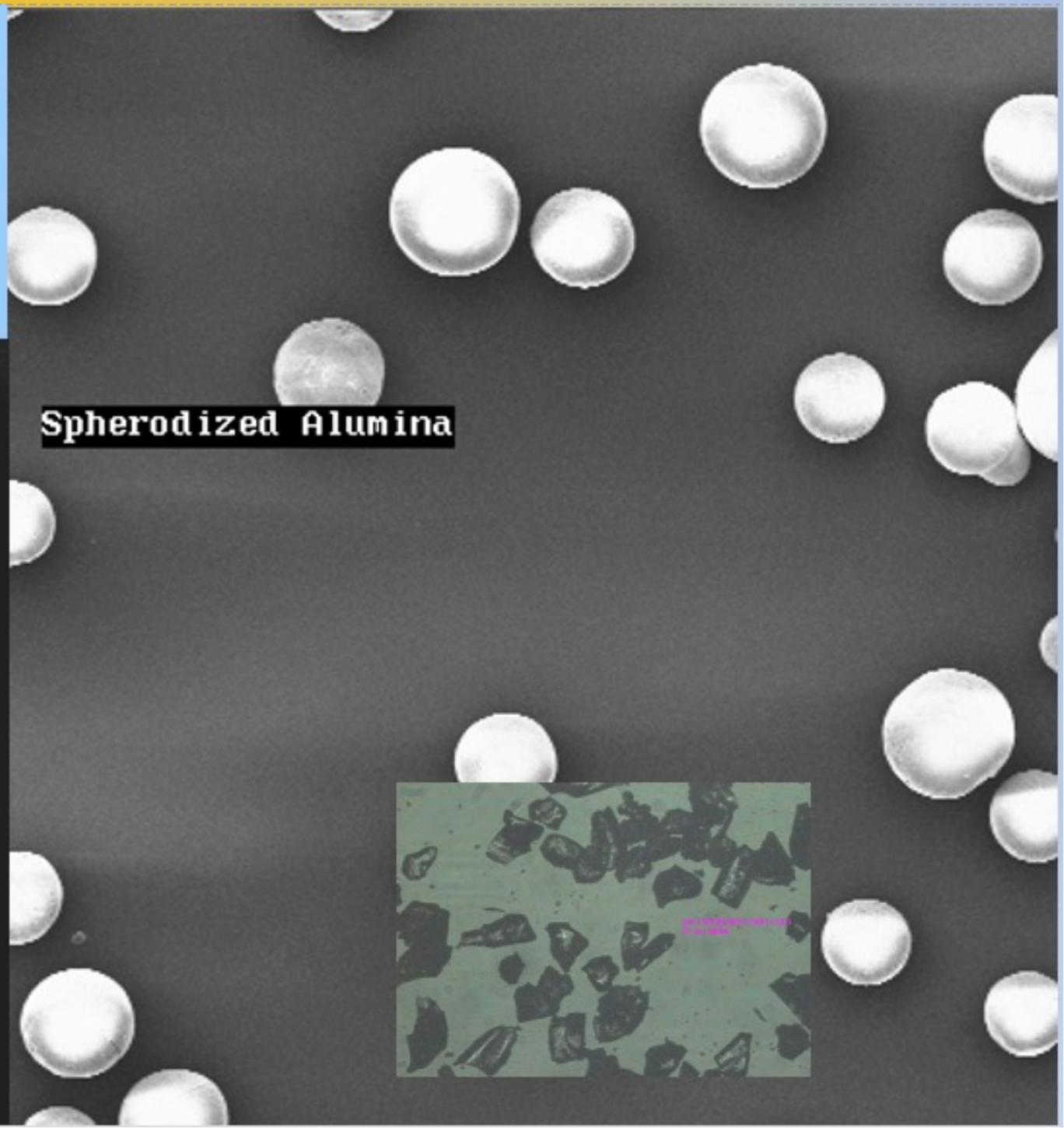
Cu/Zn + Oxidative Plasma $\Rightarrow Cu_xO + Zn_yO$ ....(1)
(Brass) Non- stoichiometric oxides

$Cu_xO + S_z$ -Rubber $\Rightarrow$ Cu_xS –Rubber ....(2)
(At the brass surface) Rubber- Brass Interface

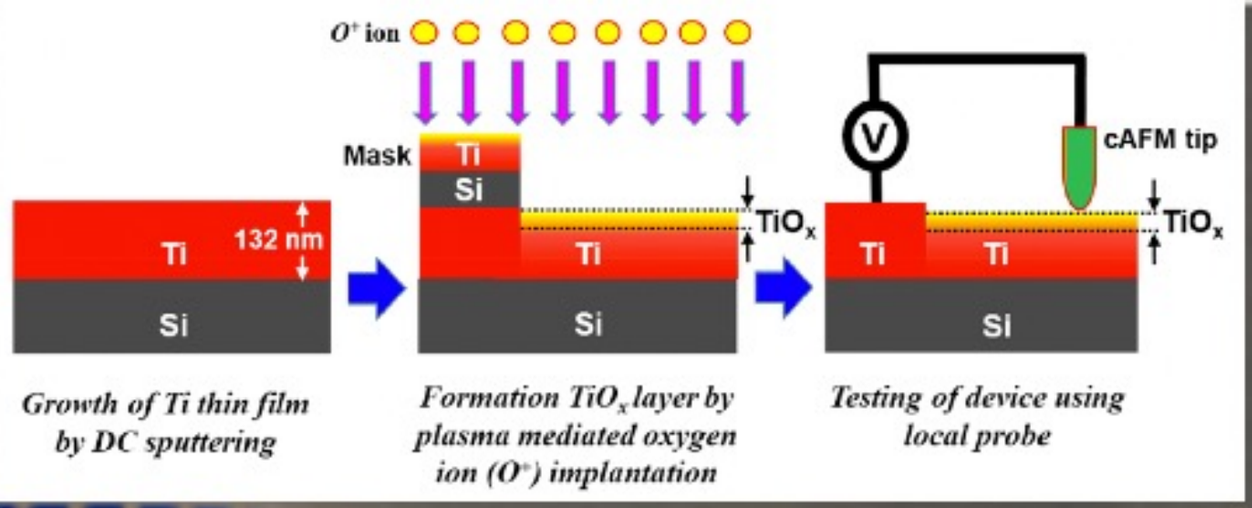
With the development of atmospheric pressure cold plasma technology, roll to roll treatment of polymers and textiles has become possible

High heat flux in thermal plasmas can produce spheroidization and densification of ceramics



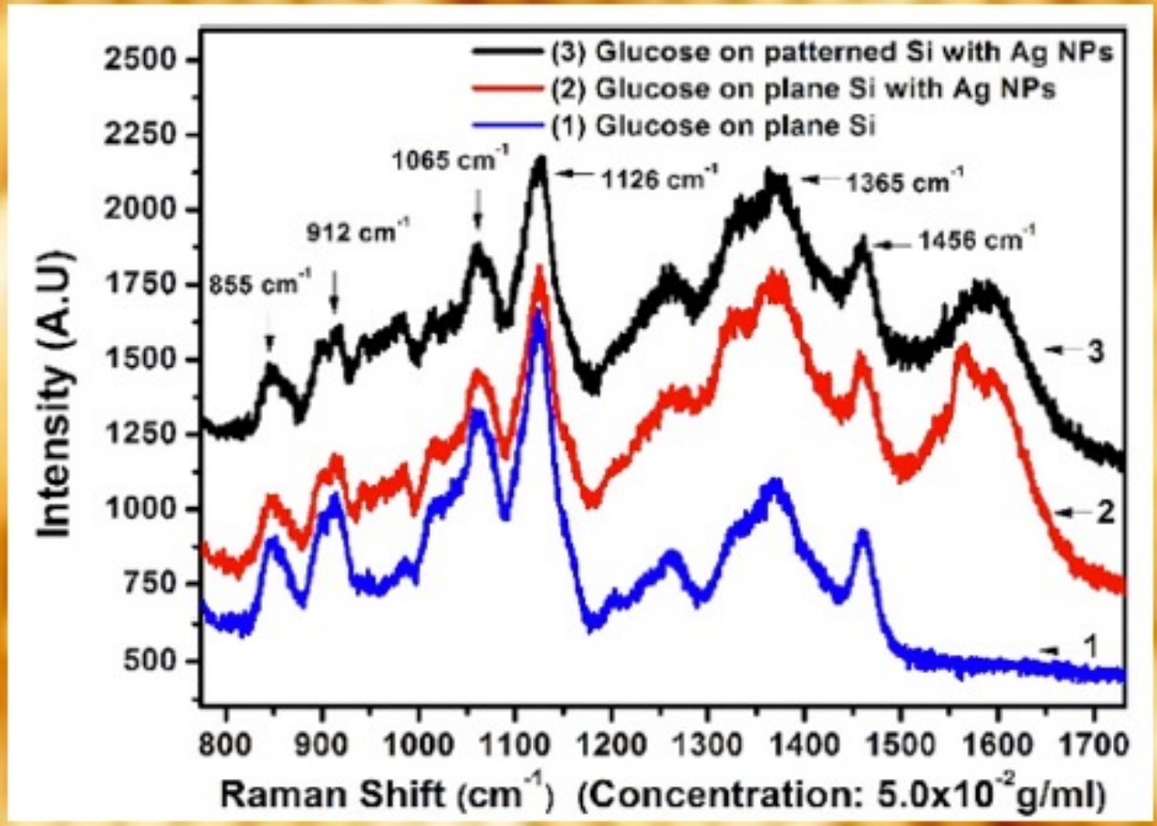


PLASMA ION IMPLANTATION FOR DEVICE FABRICATION



CREATING NANO-SCALE PATTERNS BY ION BEAM IRRADIATION

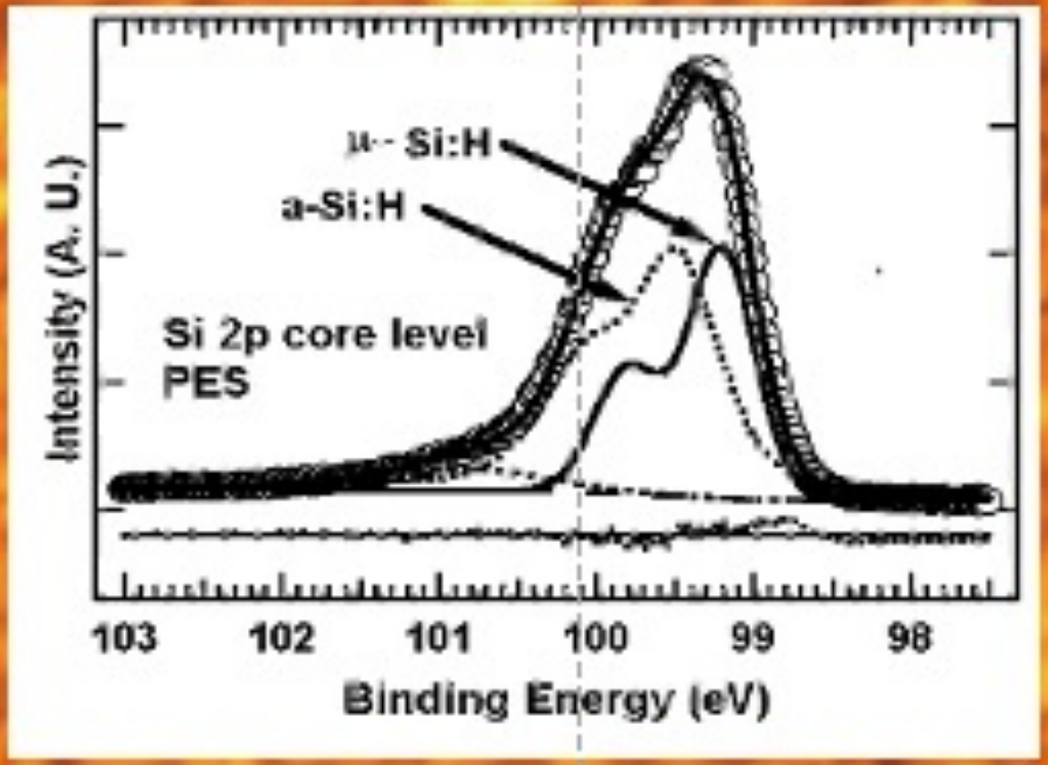
400nm



SERS based detection of glucose with lower concentration than blood glucose level

VHF PECVD process enables high rate, large area deposition of device grade microcrystalline Si:H Films

AFM revealed mixed phase, showing μ–crystallites of 500-600nm embedded in the a-Si:H matrix.



PES of Si 2p core level confirmed two types of Si species: μ–crystalline and amorphous, in the mixed phase

Plasma Etching of Angora fibres increases micro-roughness and creates surface polar groups to enhance cohesion between fibres

Low friction, poor spinnability

Plasma etch increases friction

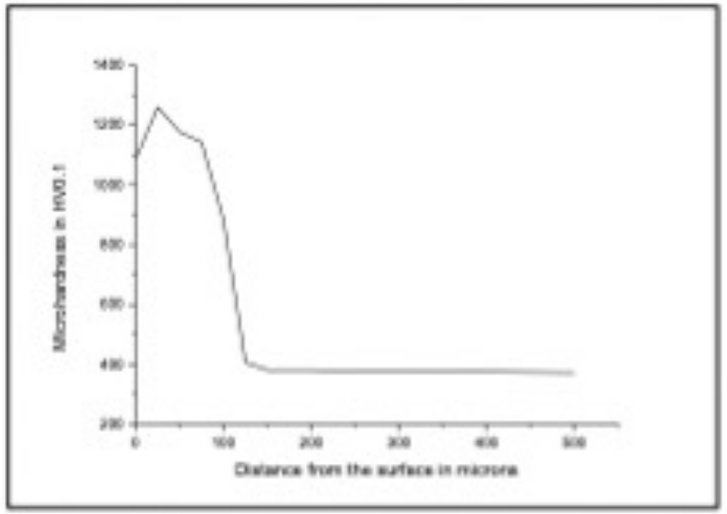
Cold Plasma Jet for Bio-medical Applications

- Faster rate of coagulation of blood. Can be used for the internal bleeding applications.
- Helps in the removal of the black spots from skin.
- Helps in the sterilization and bleaching of teeth.
- Helpful in the removal of cancerous cells as this plasma does not affect healthy cells.
- Can be used in the removal of the pesticides from the vegetables.
- Can be used for hair coloring.

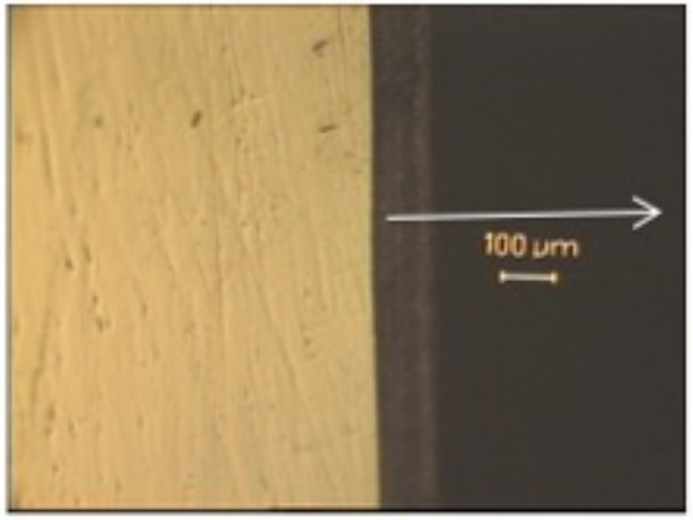
Plasma Pyrolysis System for medical waste destruction developed under TIFAC-DST support and set up at Goa Medical College, March 2004

Pollutants	CPCB Standard	Measured
CO	≤ 100 mg/nm³	40 – 85 mg/nm³
NO_x	≤ 400 mg/nm³	7-25 mg/nm³
PM	≤ 150 mg/nm³	31-105 mg/nm³
Dioxin & Furan	≤0.1 mg/nm³TEQ	≤ 0.1 mg/nm³ TEQ

Plasma Nitriding of speed reduction gears used in space crafts 1997-2002.



(a)



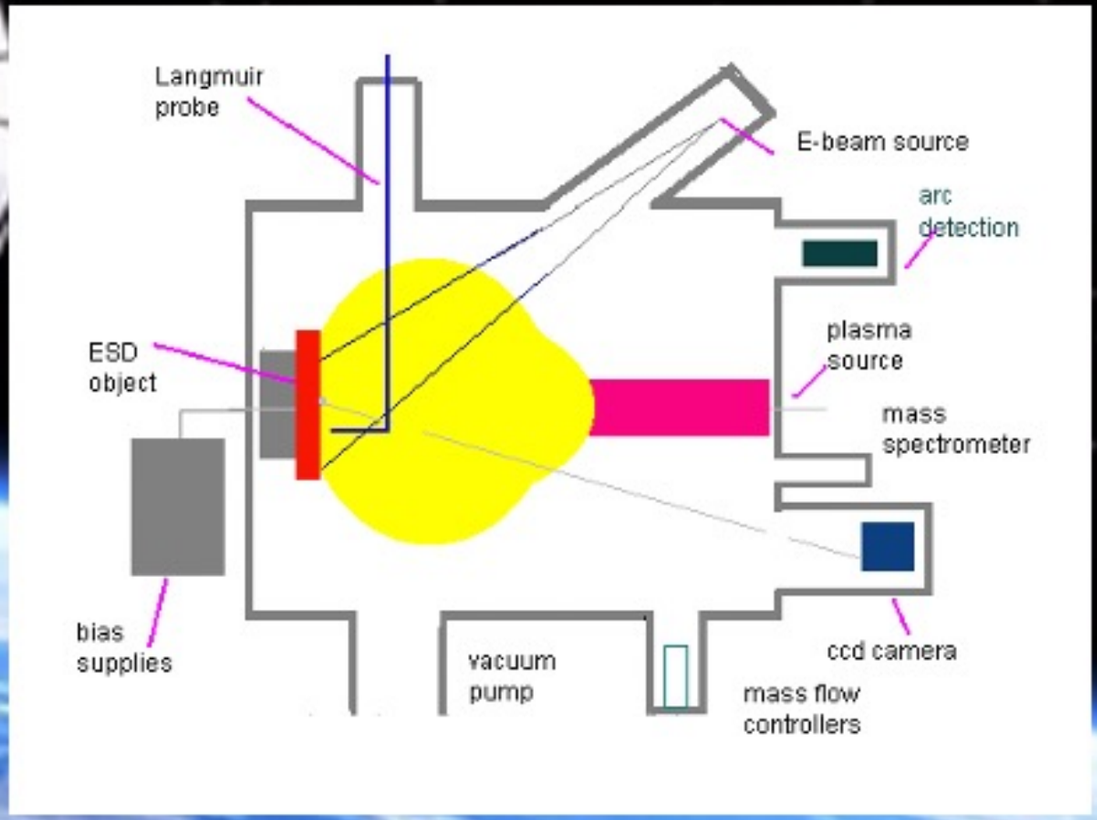
(b)

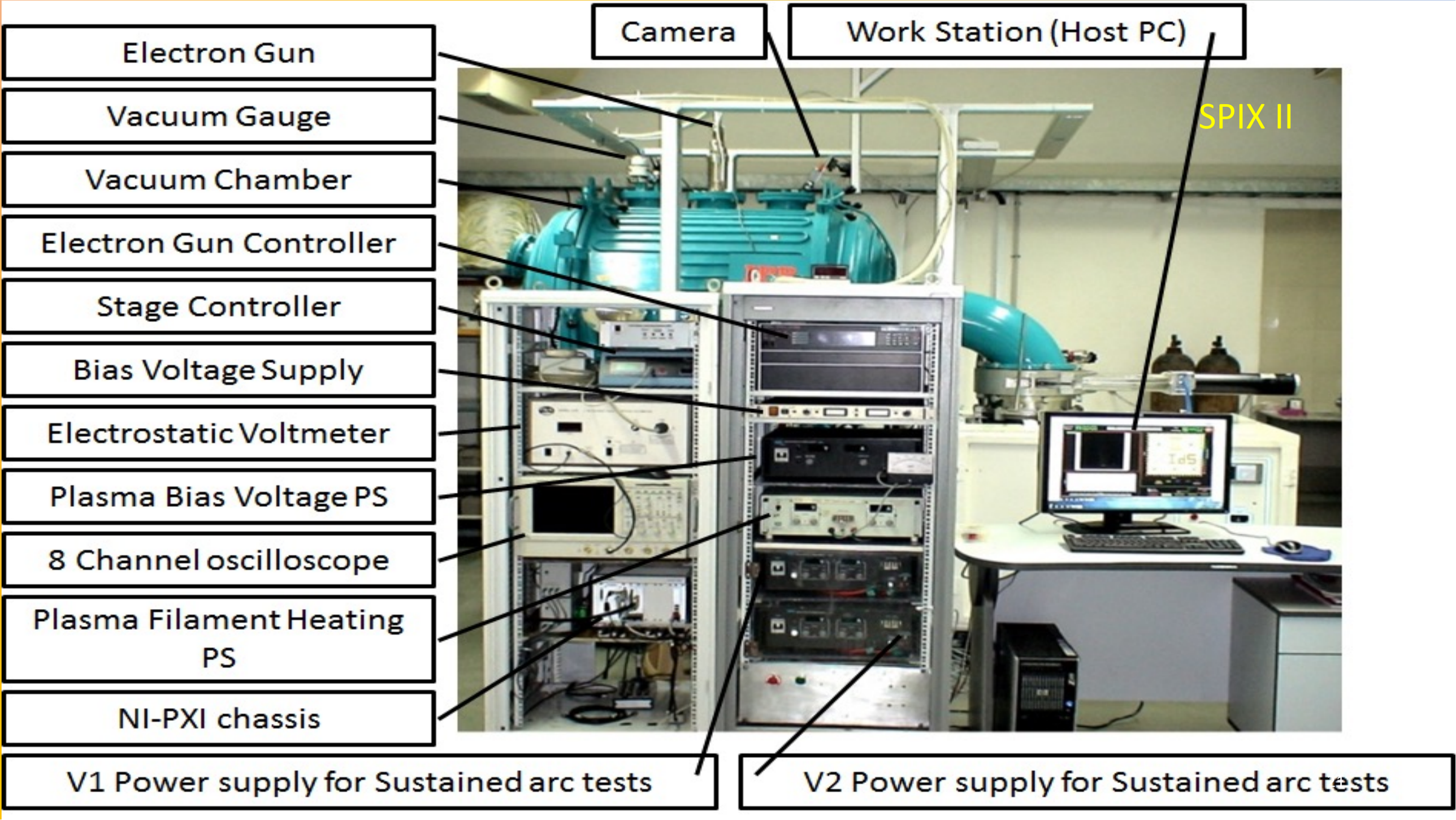
Fig. 1: Results of a) Microhardness depth profile showing surface hardness of 1100HV0.1 and b) plasma nitrided layer of 17-4Ph material showing 100 microns with no white layer after plasma nitriding.

Space-Quality Plasma Nitriding System Installed at IISU Thiruvananthapuram

Satellites in orbit are embedded in a plasma environment and the charging due to energetic electrons raise their potential over the plasma potential. The prolonged high potential state leads to arcing damaging the solar panel.

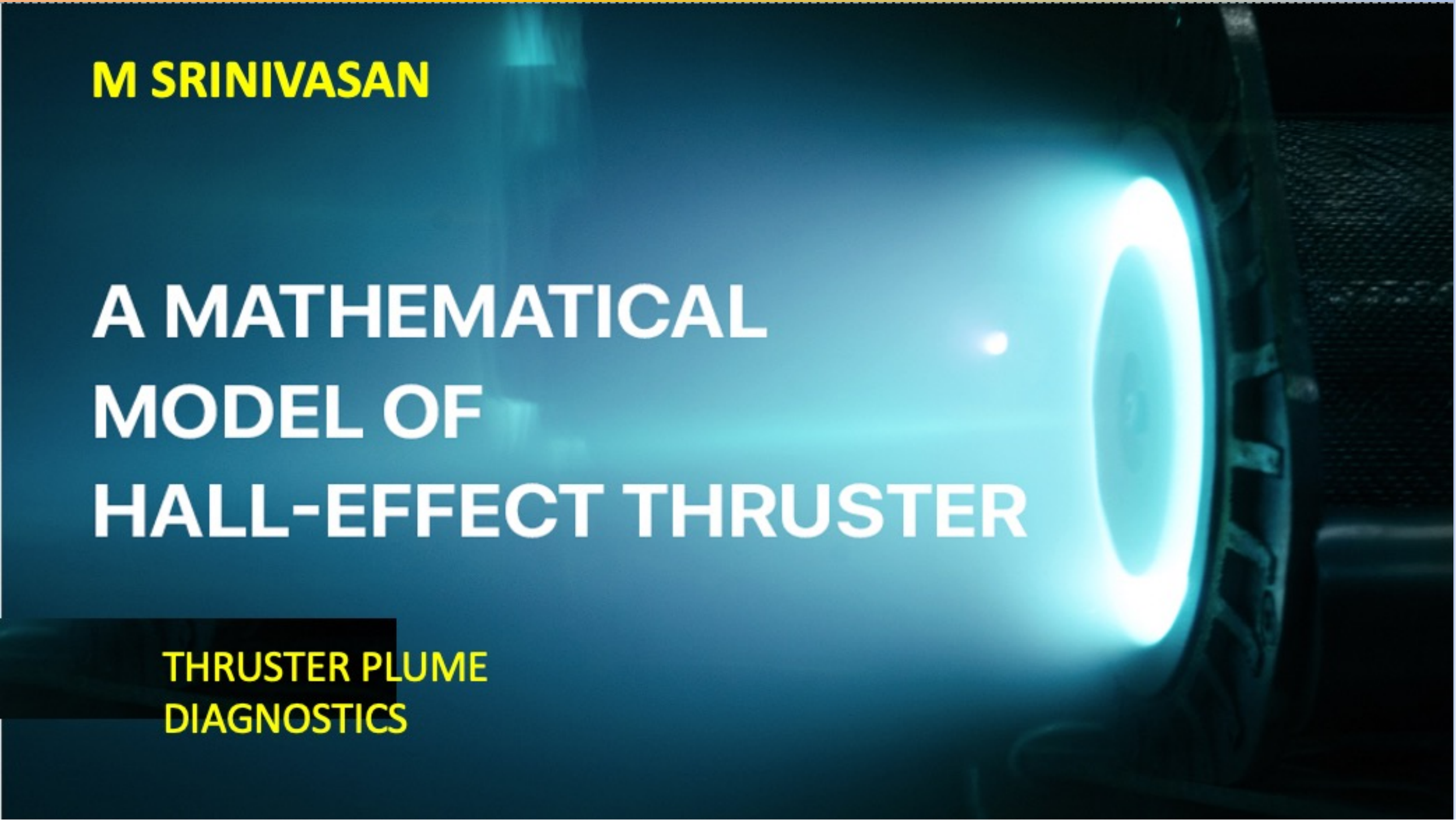
SPIX Facility




Camera
Work Station (Host PC)
SPIX II
Electron Gun
Vacuum Gauge
Vacuum Chamber
Electron Gun Controller
Stage Controller
Bias Voltage Supply
Electrostatic Voltmeter
Plasma Bias Voltage PS
8 Channel oscilloscope
Plasma Filament Heating PS
NI-PXI chassis
V1 Power supply for Sustained arc tests
V2 Power supply for Sustained arc tests

M SRINIVASAN

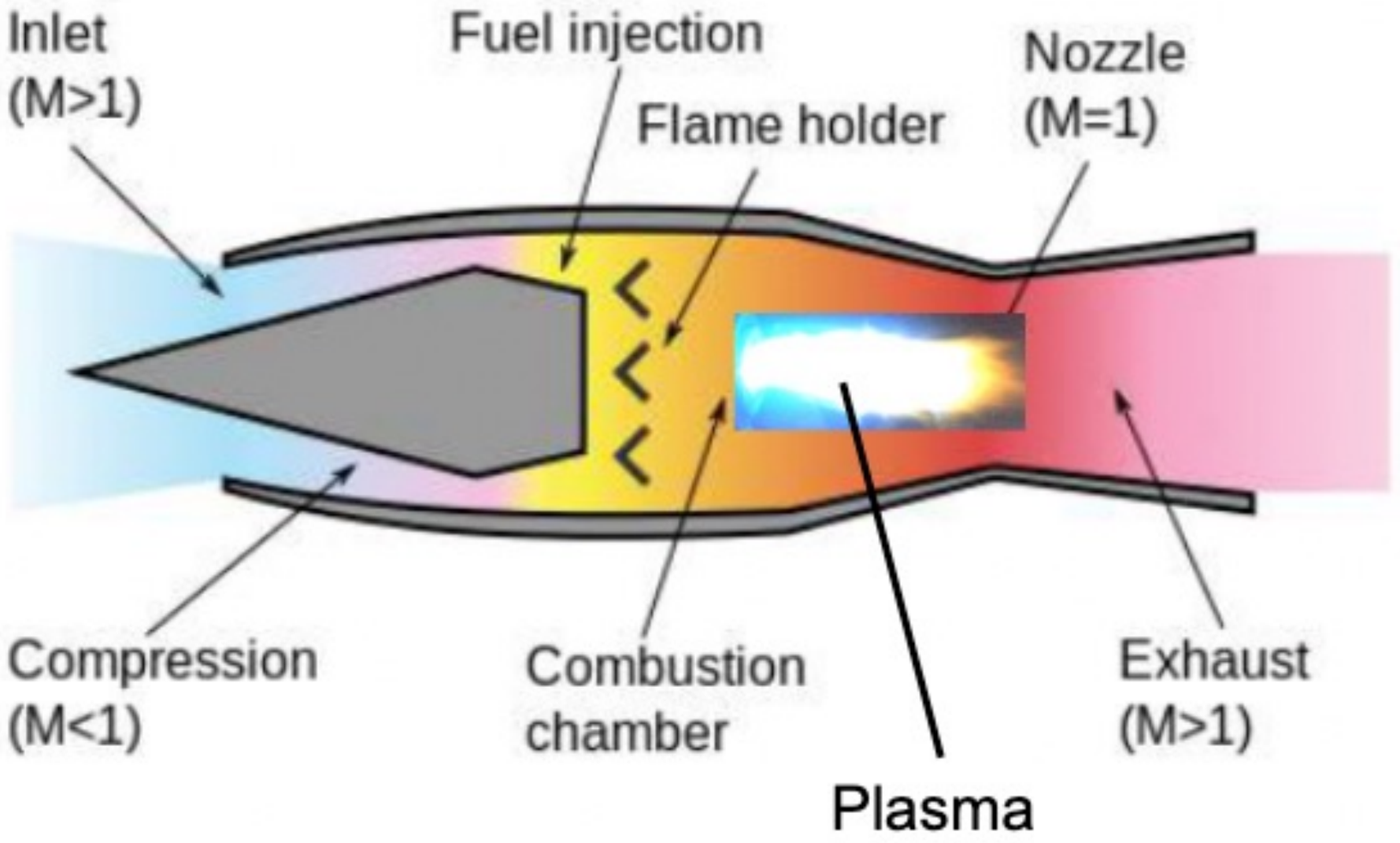
A MATHEMATICAL MODEL OF HALL-EFFECT THRUSTER

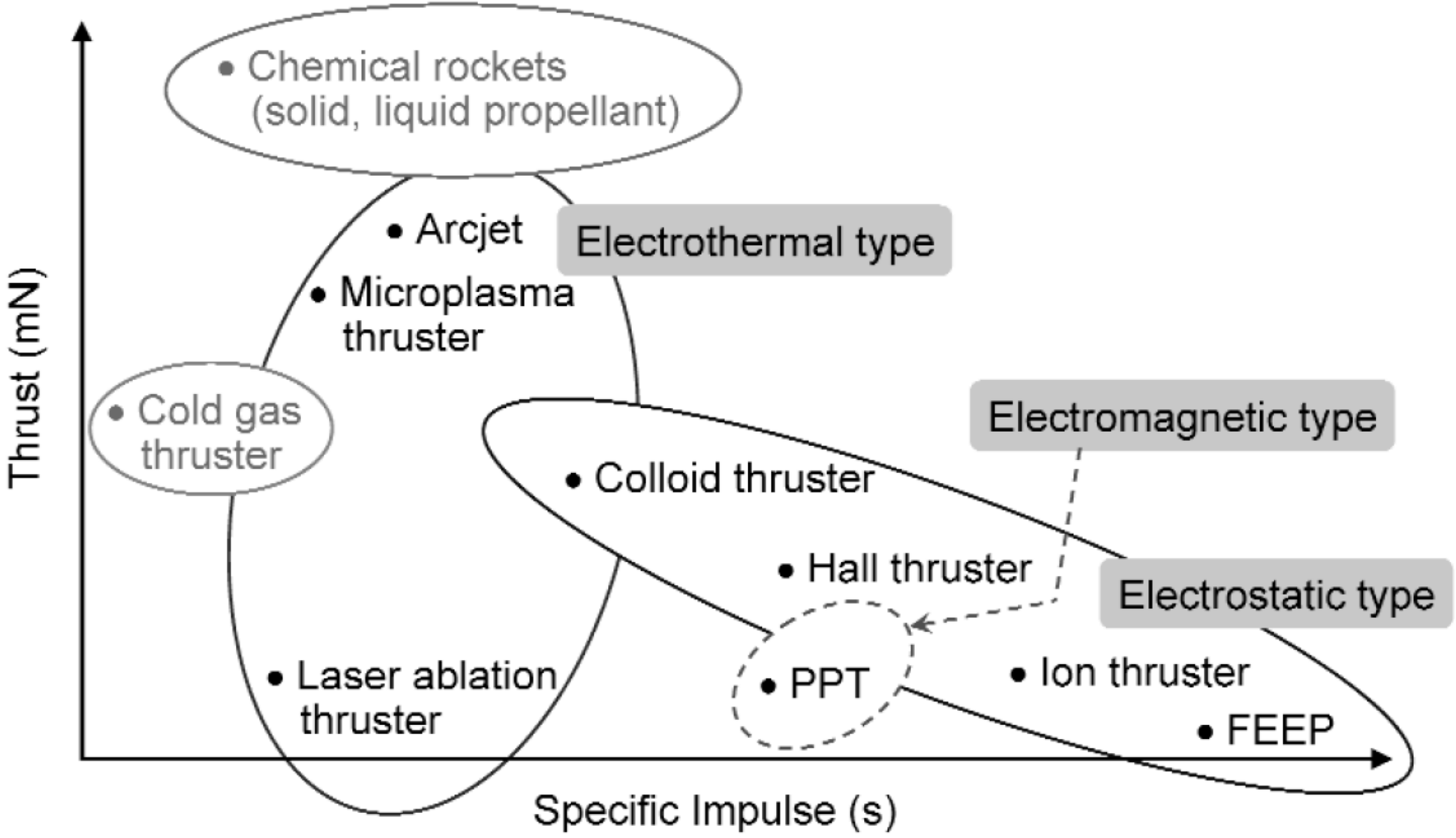


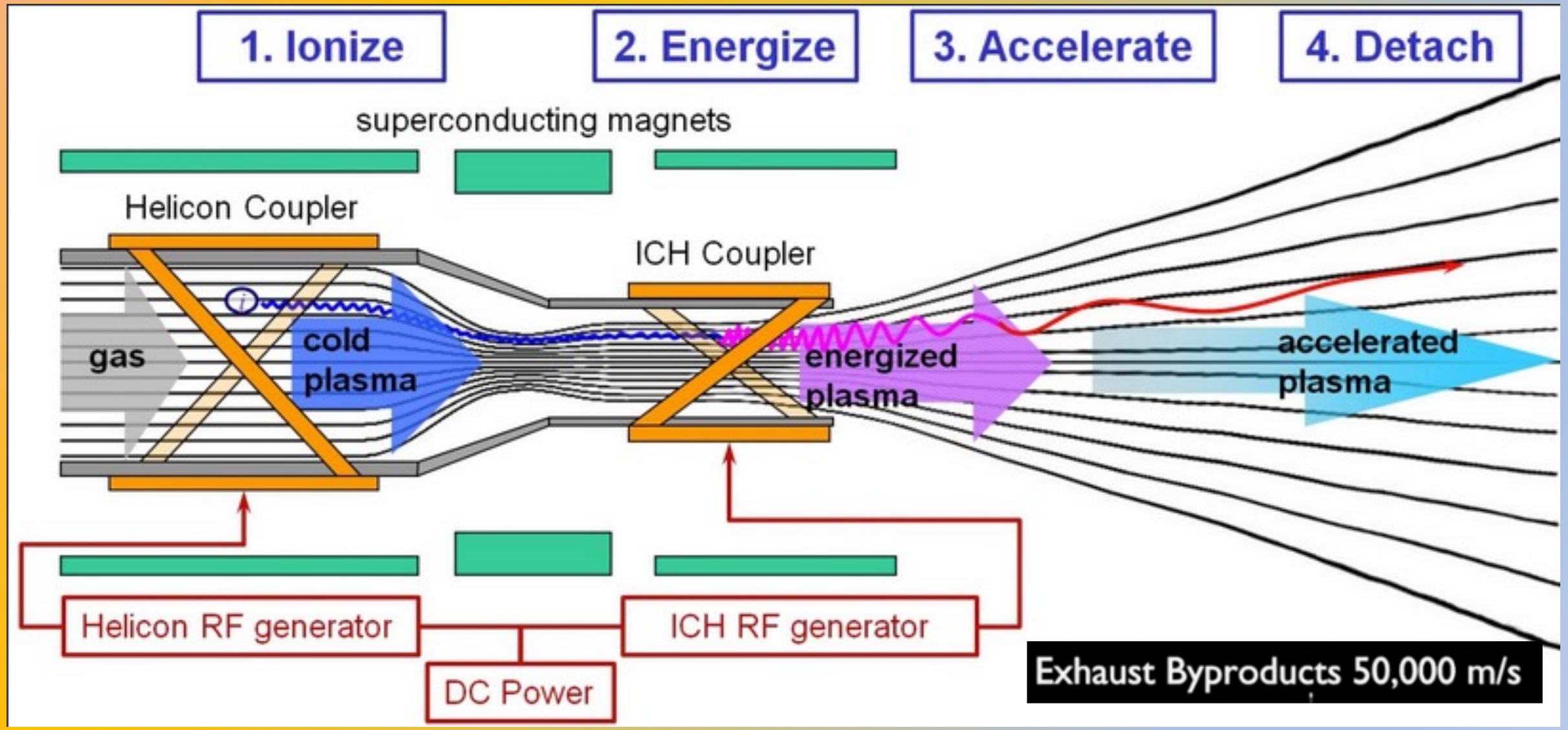
THRUSTER PLUME DIAGNOSTICS

COSPAR Planetary Protection Policy has sought to protect the space environment from “harmful contamination” which would endanger the integrity of the scientific exploration of outer space including the search for life

PLASMA ASSISTED COMBUSTION




• Chemical rockets
(solid, liquid propellant)
• Arcjet
Electrothermal type
• Microplasma
thruster
• Cold gas
thruster
Electromagnetic type
• Colloid thruster
• Hall thruster
Electrostatic type
• Laser ablation
thruster
• PPT
• Ion thruster
• FEEP
Thrust (mN)
Specific Impulse (s)



Variable Specific Impulse Magnetoplasma Rocket VASIMR