# An overview of Plasma Activities at Kathmandu University

**D. P. Subedi**
Dept. of Physics, School of Science, Kathmandu University

# Outline

1. Brief Introduction to Kathmandu University
2. Plasma Research in KU
   - 2.1 Plasma Generation
   - 2.2 Plasma Diagnostics
   - 2.3 Plasma Application
3. Physics related activities organized by KU
4. Future Plan

# A brief Introduction to Kathmandu University

Kathmandu University (KU) was established in **1991**. This is an autonomous, not-for-profit, non - government institution dedicated to maintain high standards of academic excellence. It is committed to develop leaders in professional areas through quality education.

## Vision

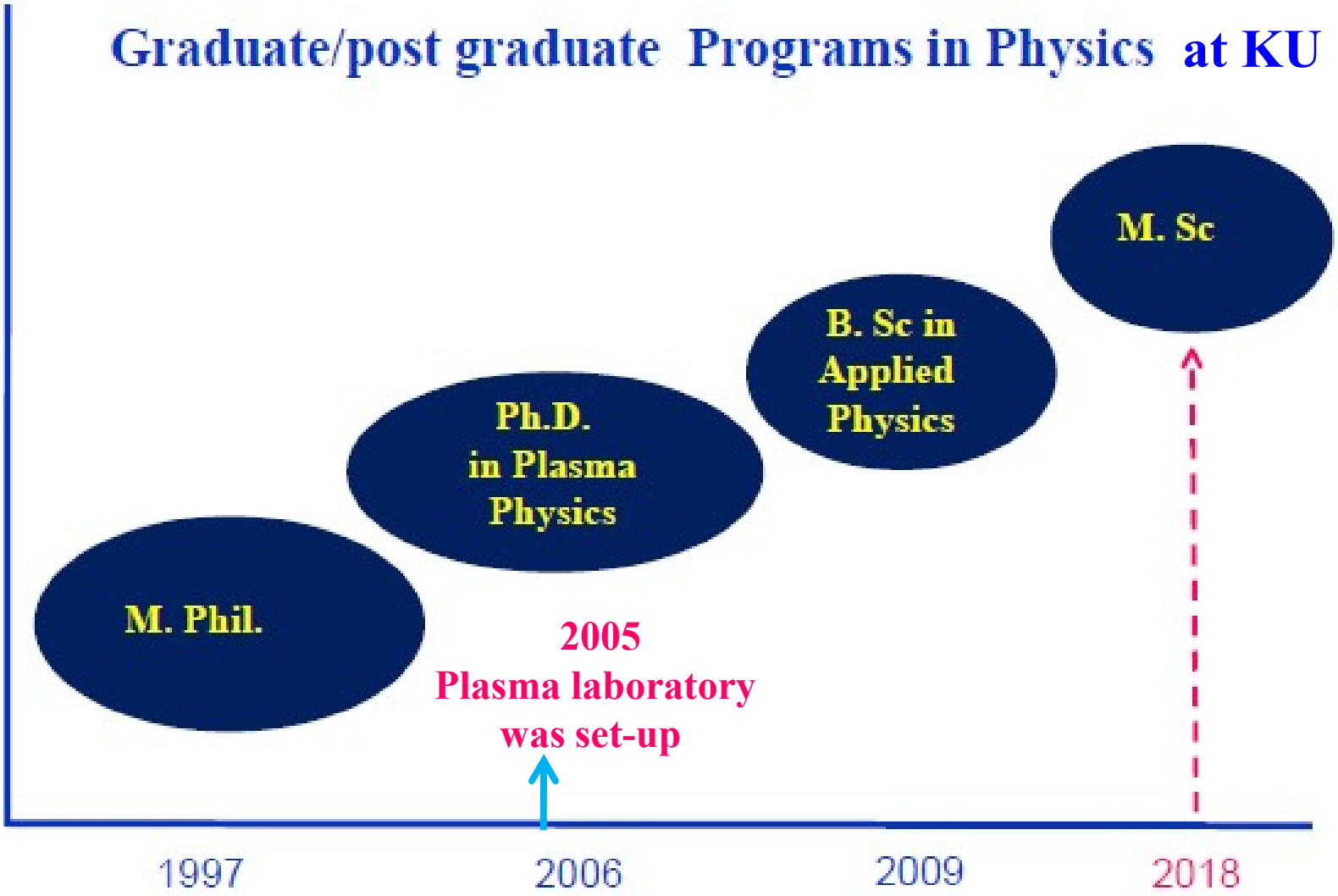
"To become a world-class university devoted to bringing knowledge and technology to the service of mankind

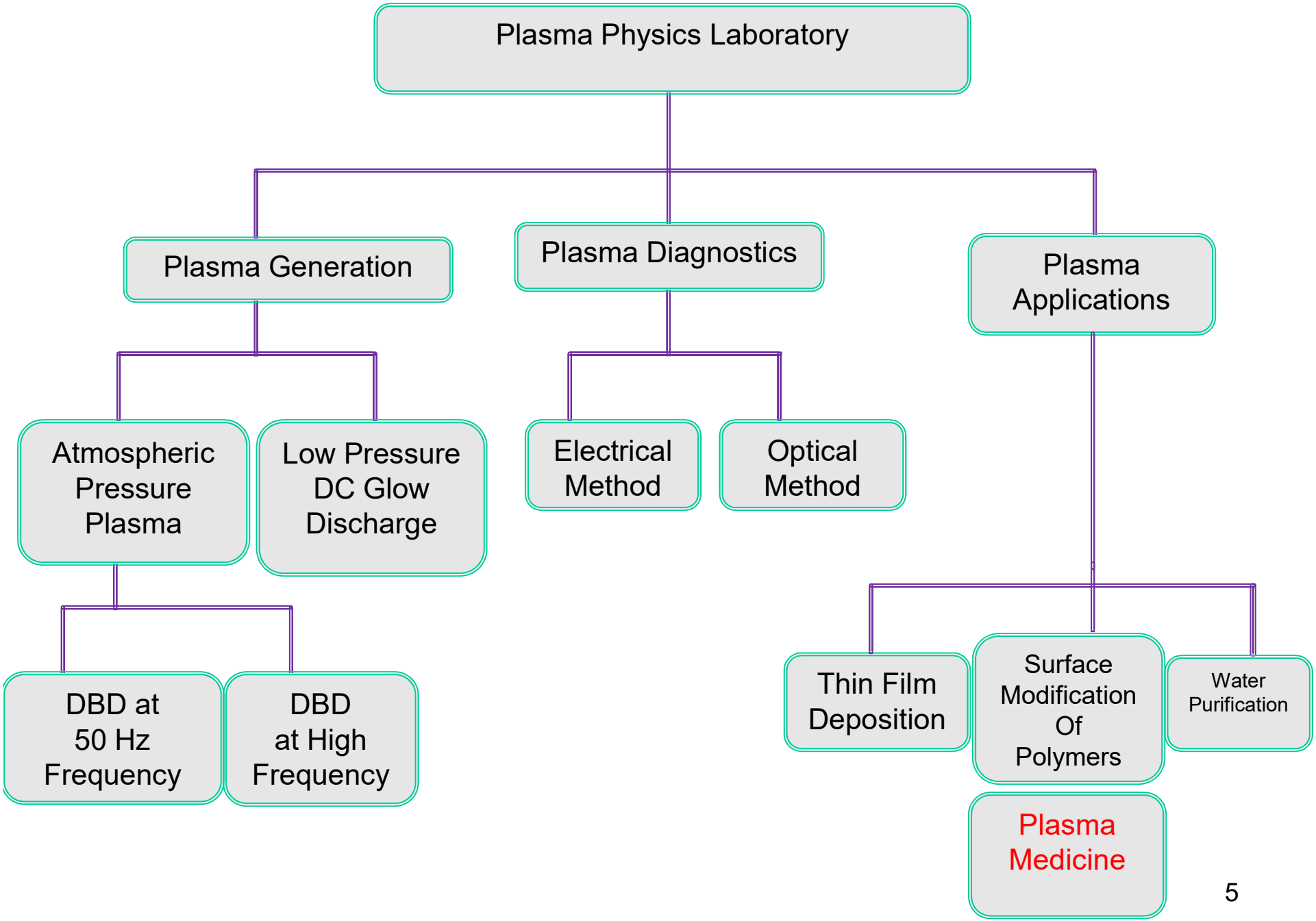
## Mission

"To provide quality education for leadership"

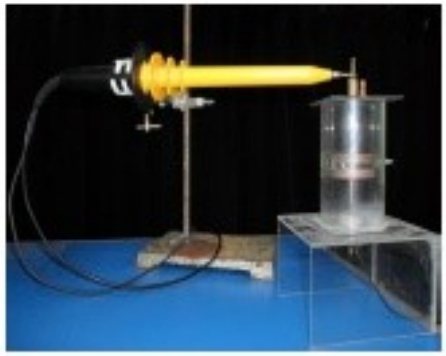
**KU Silver Jubilee Initiatives**

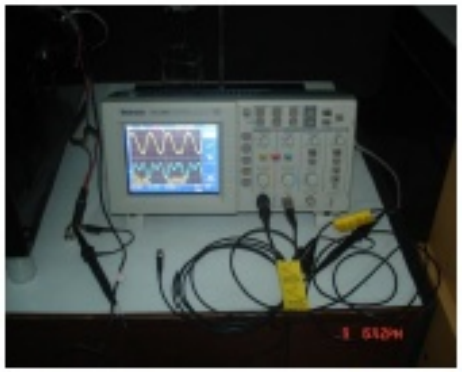
- **Quality**
- **Equity**
- **Identity**
- **Impact**
- **Innovation**
- **Global Engagement**


Graduate/post graduate Programs in Physics at KU
M. Sc
B. Sc in Applied Physics
Ph.D. in Plasma Physics
M. Phil.
2005
Plasma laboratory was set-up
1997
2006
2009
2018

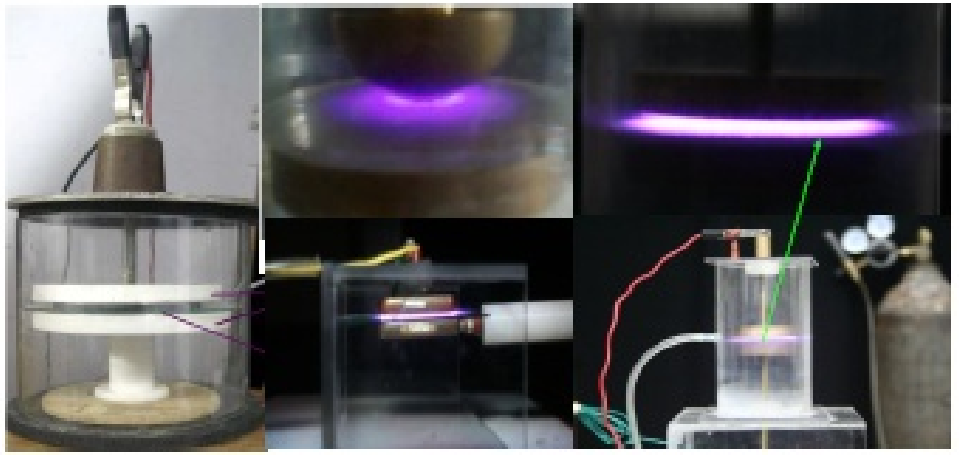

Plasma Physics Laboratory
Plasma Generation
Plasma Diagnostics
Plasma Applications
Atmospheric Pressure Plasma
Low Pressure DC Glow Discharge
Electrical Method
Optical Method
DBD at 50 Hz Frequency
DBD at High Frequency
Thin Film Deposition
Surface Modification Of Polymers
Water Purification
Plasma Medicine

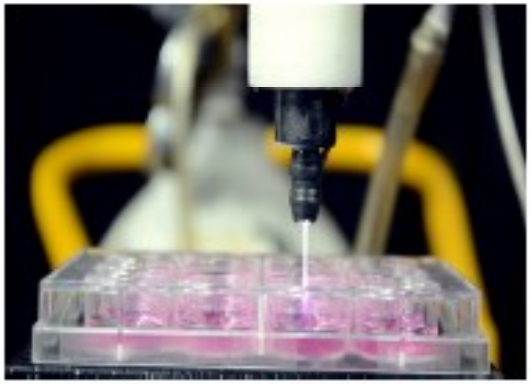
# Plasma Research Facilities at KU

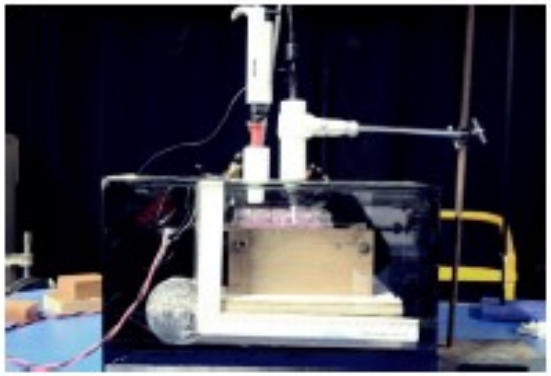



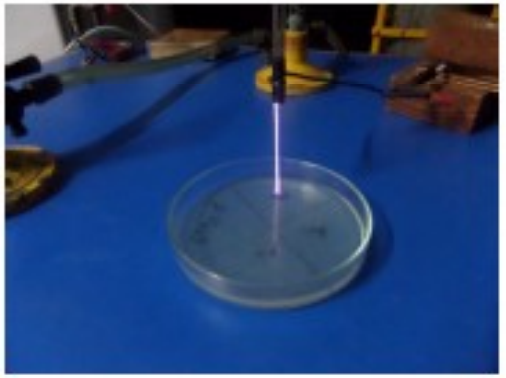



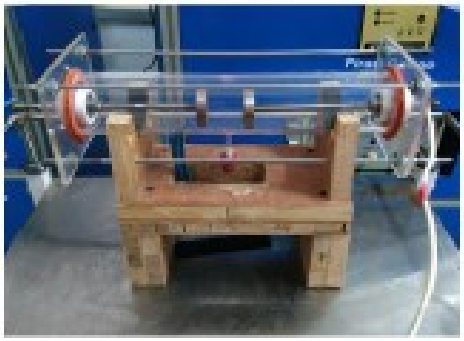
# Plasma Research Facilities at KU











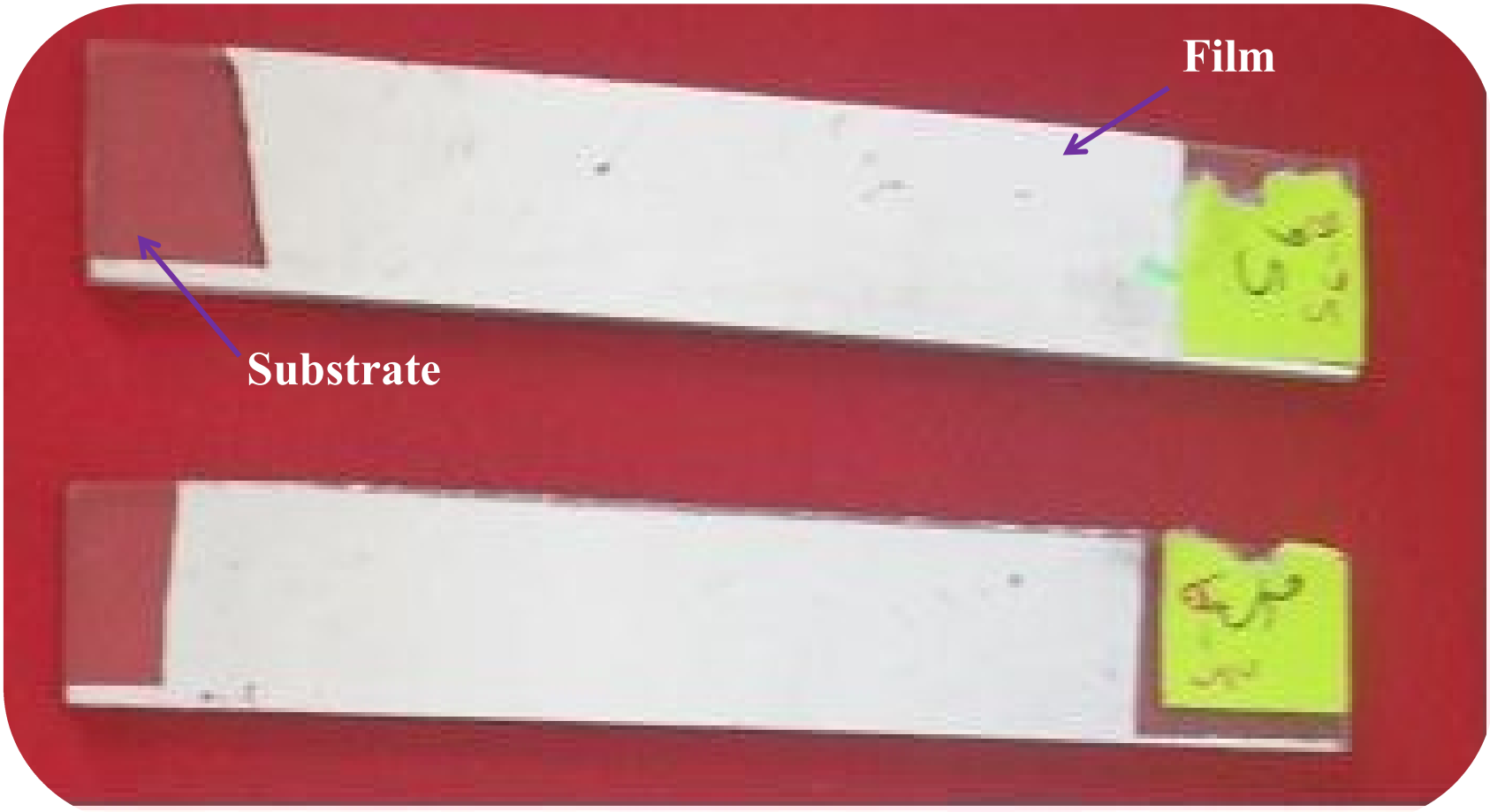
# Plasma reactor used for thin film deposition

The system is used for training research students (Ph.D., M. Phil & M.Sc.) in the field of film deposition technology.

The important parts of the system

1. Vacuum Chamber
2. Rotary pump
3. Diffusion pump
4. Pirani gauge
5. Penning gauge
6. Control unit- *In situ* thickness monitoring

# Deposition of Thin Films

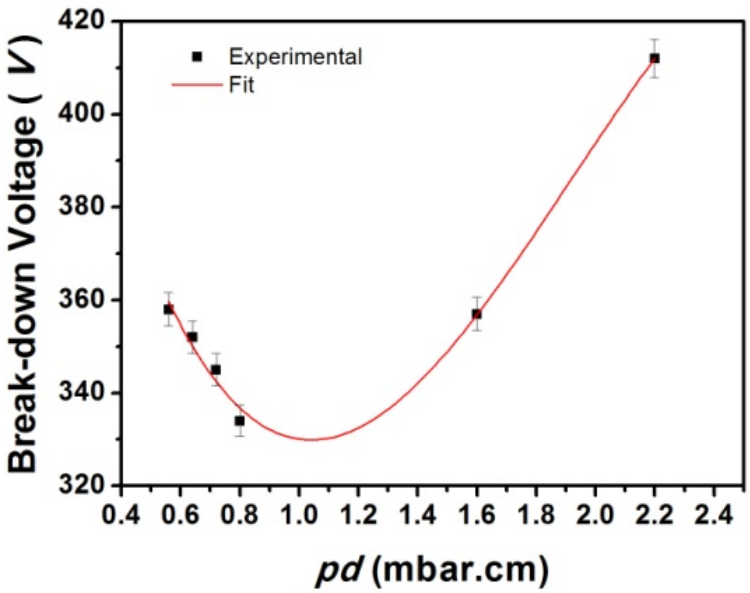


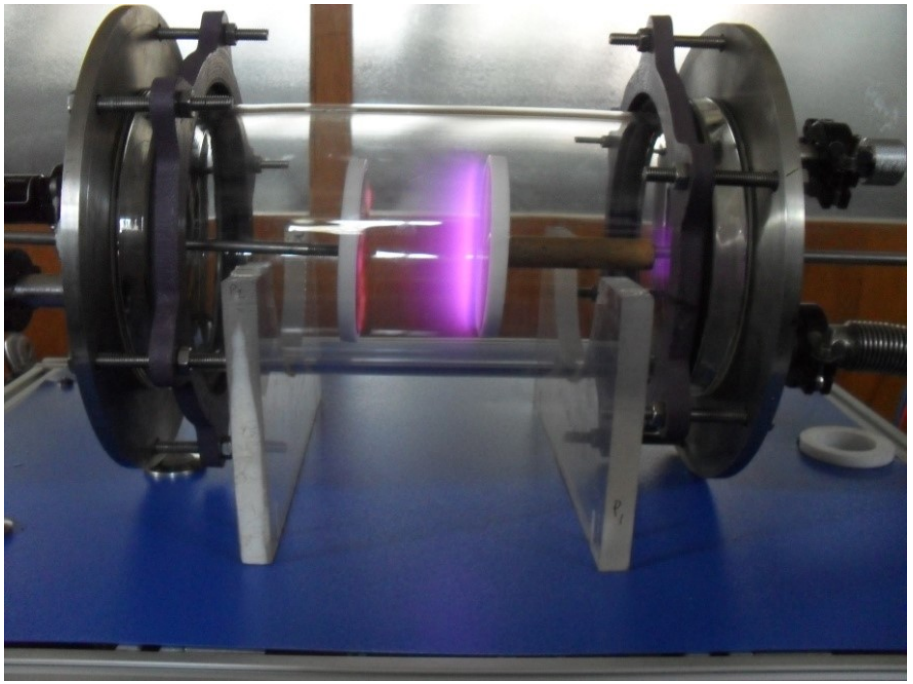
# Low Pressure DC Glow discharge systems

# Paschen Curve

- Breakdown of a gas in uniform dc electric field is given by Paschen's law

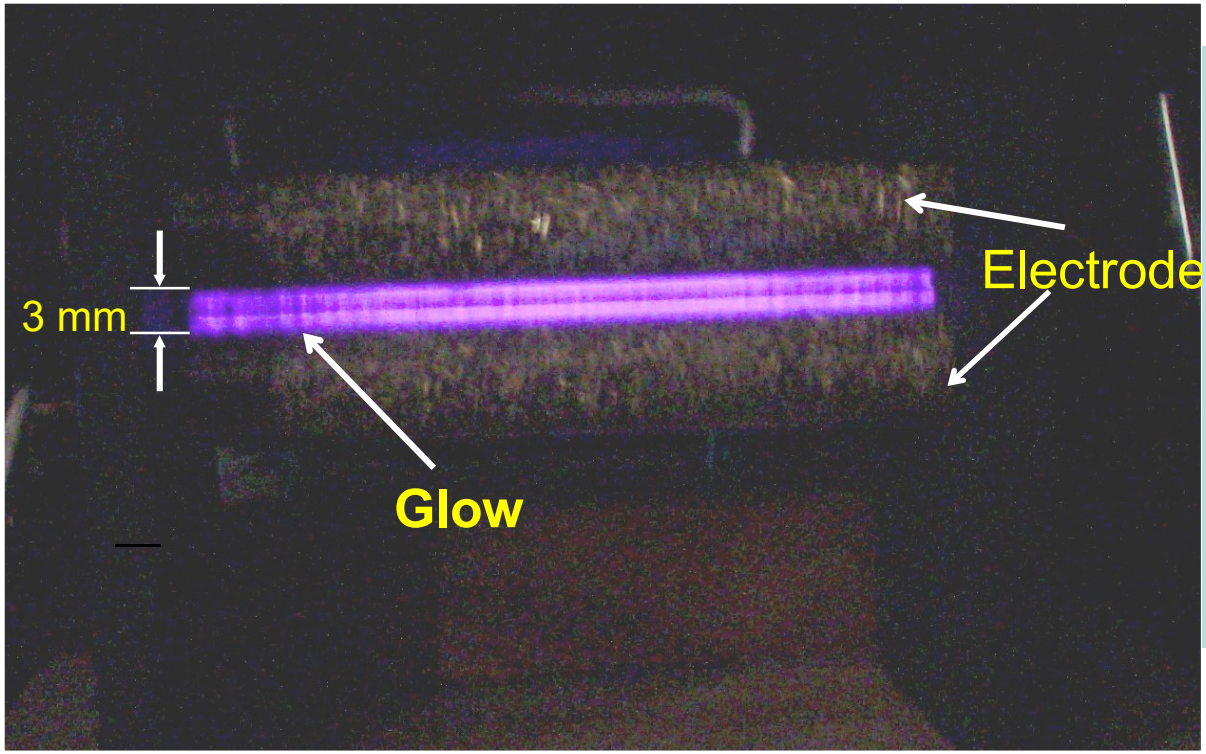
$$V = \frac{a(pd)}{\ln(pd) + b}$$



J. Alphonsa and A. Satyaprasad

# Dielectric Barrier Discharge (DBD) in Air

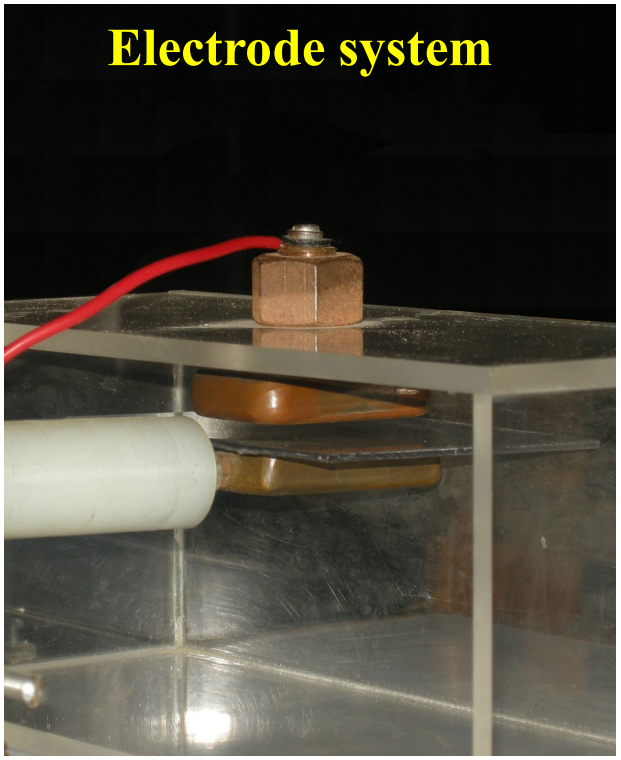


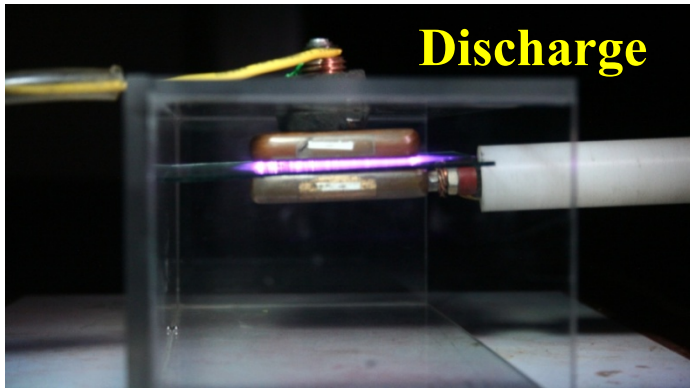

Produced using High voltage-AC Power supply Operating at a frequency of 10-30 kHz.
with double barrier.
This system has been used for studying plasma surface modification of polymers and textiles.

G. Shrestha, P. Freere, S. M. Basnet, W.T. Jewel and D. P. Subedi,
IEEE, Region 5 Technical Conference, pp. 432-435, 2007

# Atmospheric Pressure DBD using a 50 Hz HV power supply

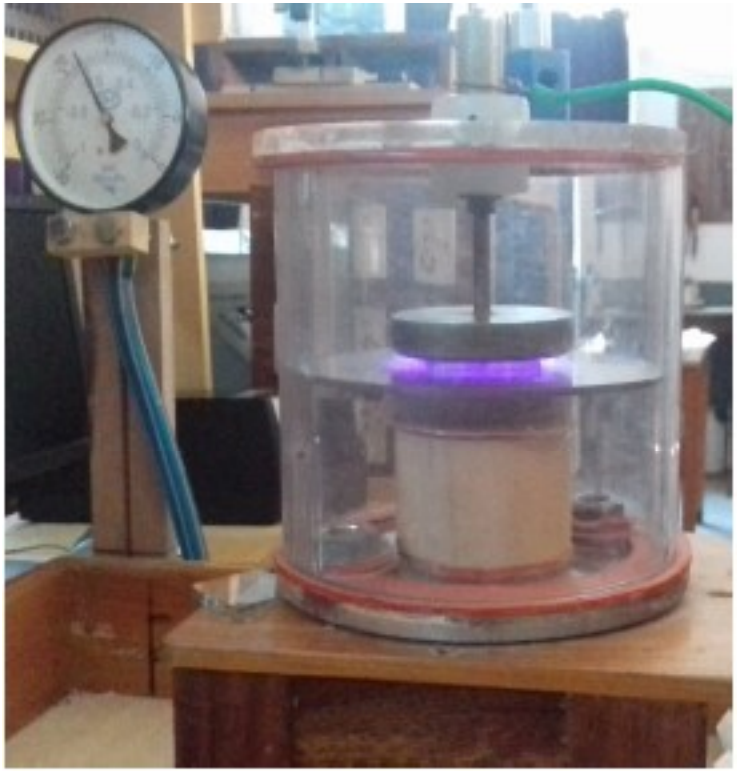





Copper electrode:
5 cm × 3.5 cm × 1 cm

# DBD at Near Atmospheric Pressure



# Development of a Cold Plasma Generator for Atmospheric Pressure Dielectric Barrier Discharge

*G. Shrestha, P. Freere, S. M. S. Basnet, W. T. Jewell, D.P. Subedi*

Keywords -- Plasma, dielectric barrier discharge, high voltage high frequency generator.

II. DIELECTRIC BARRIER DISCHARGE

1-4244-1280-3/07/$25.00 ©2007 IEEE

2007 IEEE Region 5 Technical Conference, April 20-21, Fayetteville, AR

AIP ADVANCES 7, 085213 (2017)

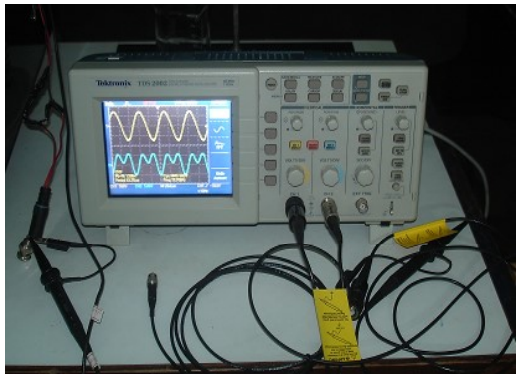
# Improvement of wettability and absorbancy of textile using atmospheric pressure dielectric barrier discharge

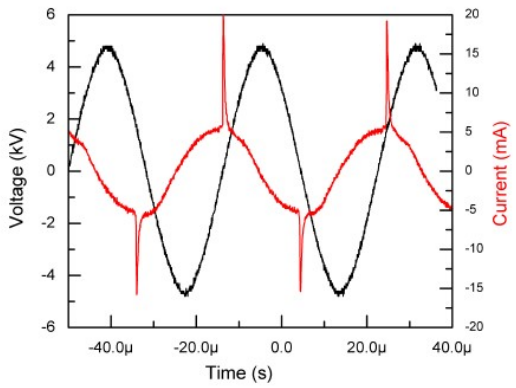
Bhagirath Ghimire,[1,2,a] Deepak Prasad Subedi,[2] and Raju Khanal[3]
[1]*Department of Physics, Patan Campus, Lalitpur, Nepal*
[2]*Department of Natural Sciences, Kathmandu University, Dhulikhel, Nepal*
[3]*Central Department of Physics, Kirtipur, Kathmandu, Nepal*

(Received 27 June 2017; accepted 7 August 2017; published online 16 August 2017)

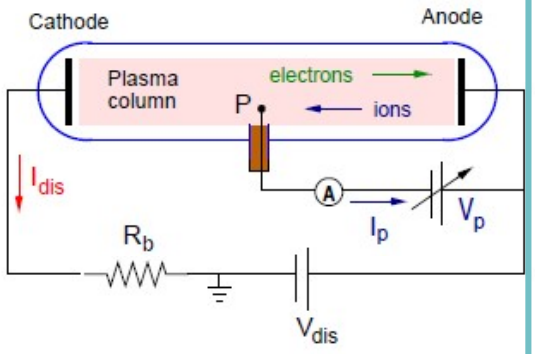
# Plasma Diagnostics

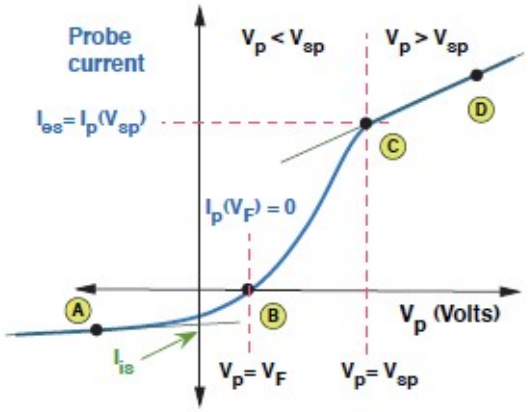
## I-V measurement For DBD



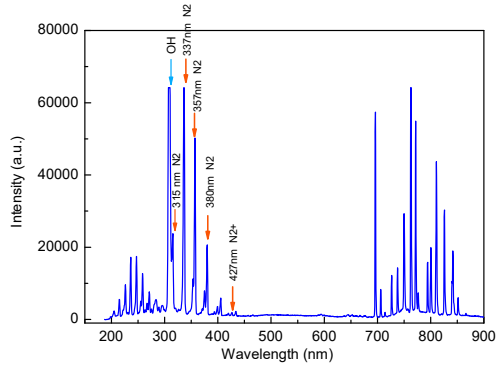



## Langmuir probe



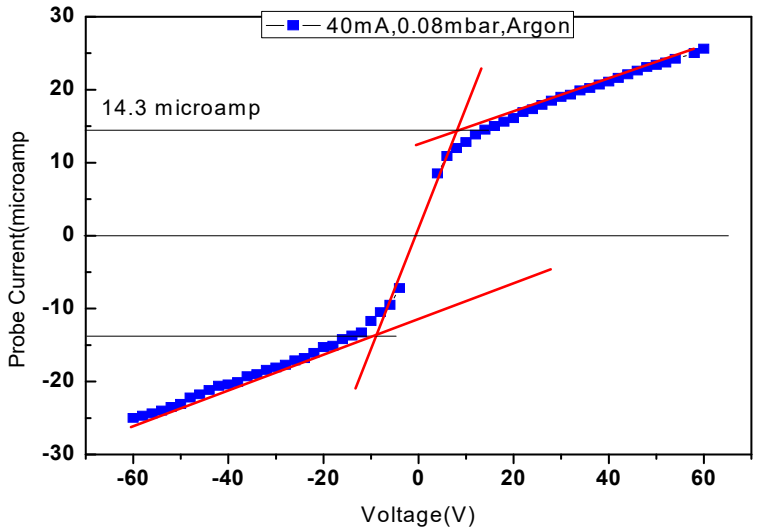




## Optical Emission Spectrometer



# Plasma Diagnostics: Double Probe

- Double probe, uses 2 metallic wires or same dimensions immersed in low pressure plasma.
- Using double probe theory plasma parameters ($n_i$, $T_e$) can be obtained




| Parameter | Range |
|---|---|
| Gas | Argon |
| Discharge Current | 0.04 A |
| Electron Temperature | 4 eV |
| Plasma Density | 5 x $10^9$/$cm^3$ |
| Ion Saturation | 14-15micro amp |


R. Rane and S. Mukherjee

# Diagnostics of Atmospheric pressure plasma

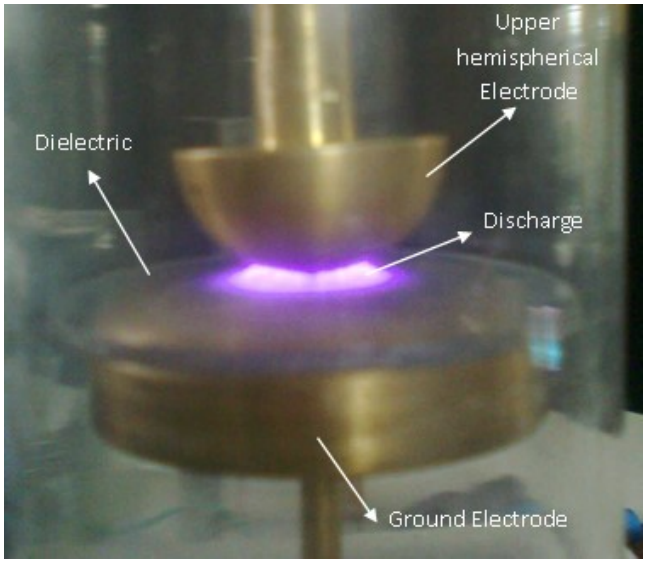
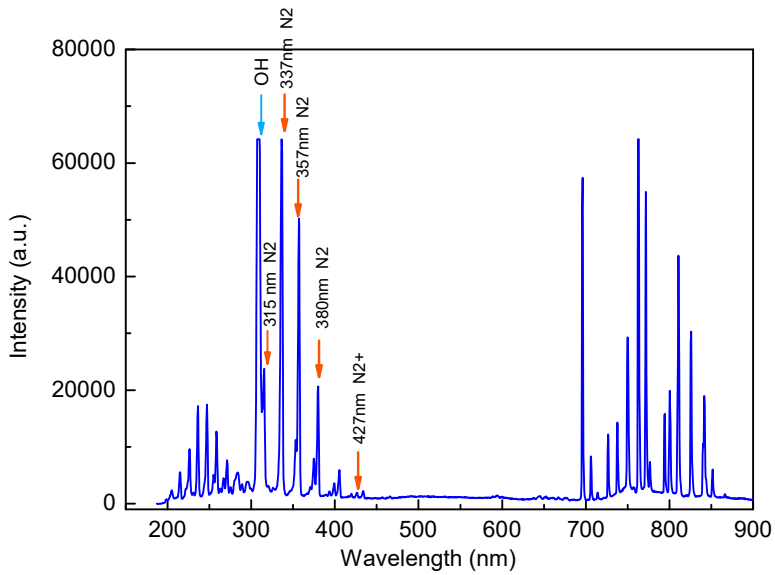


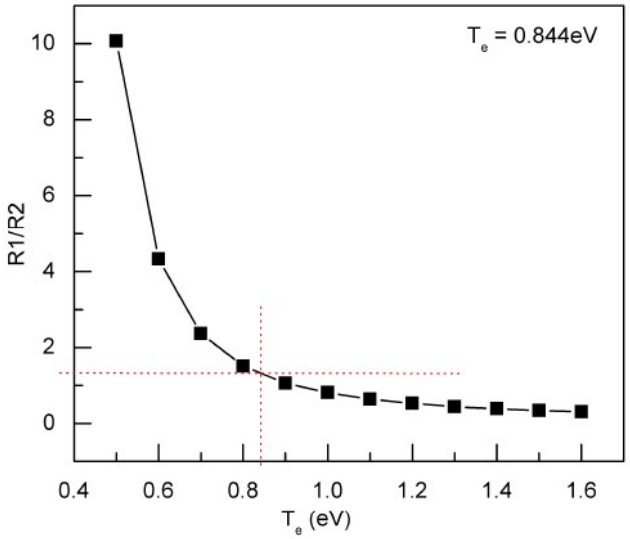

Fig: Photograph of discharge Hemispherical Electrode

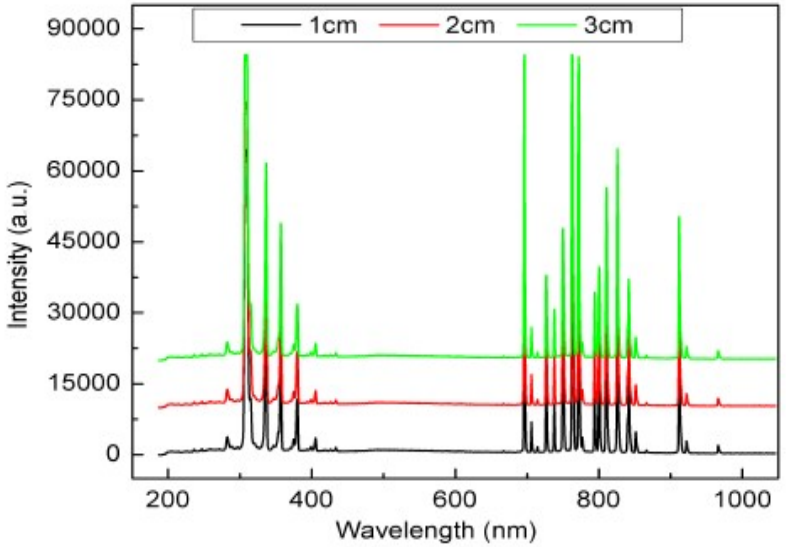


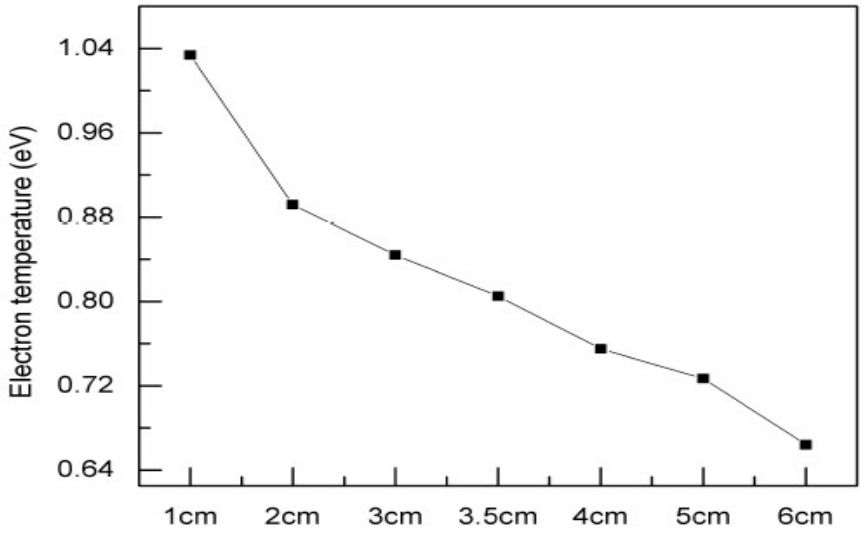
# Electron Temperature (Line intensity ratio method)

$$\frac{R_1}{R_2}=\frac{I_1/I_2}{I_3/I_4}=\left(\frac{A_{pq}}{A_{xy}}\right)\left(\frac{g_p}{g_x}\right)\left(\frac{\lambda_{xy}}{\lambda_{pq}}\right)\left(\frac{A_{uv}}{A_{rs}}\right)\left(\frac{g_u}{g_r}\right)\left(\frac{\lambda_{rs}}{\lambda_{uv}}\right)\exp\left[-\frac{E_p-E_x-E_r+E_u}{kT_e}\right]-$$

| | | | |
|---|---|---|---|
| ArI (696.54 nm) | $A_{pq}=6.39\times10^6$ | $g_p=5$ | $E_p=11.564$ eV |
| ArI (751.034 nm) | $A_{rs}=4.02\times10^7$ | $g_r=3$ | $E_r=11.636$ eV |
| ArII (314.13 nm) | $A_{xy}=5.20\times10^7$ | $g_x=6$ | $E_x=19.249$ eV |
| ArII (378.75 nm) | $A_{uv}=10.5\times10^6$ | $g_u=8$ | $E_u=16.797$ eV |



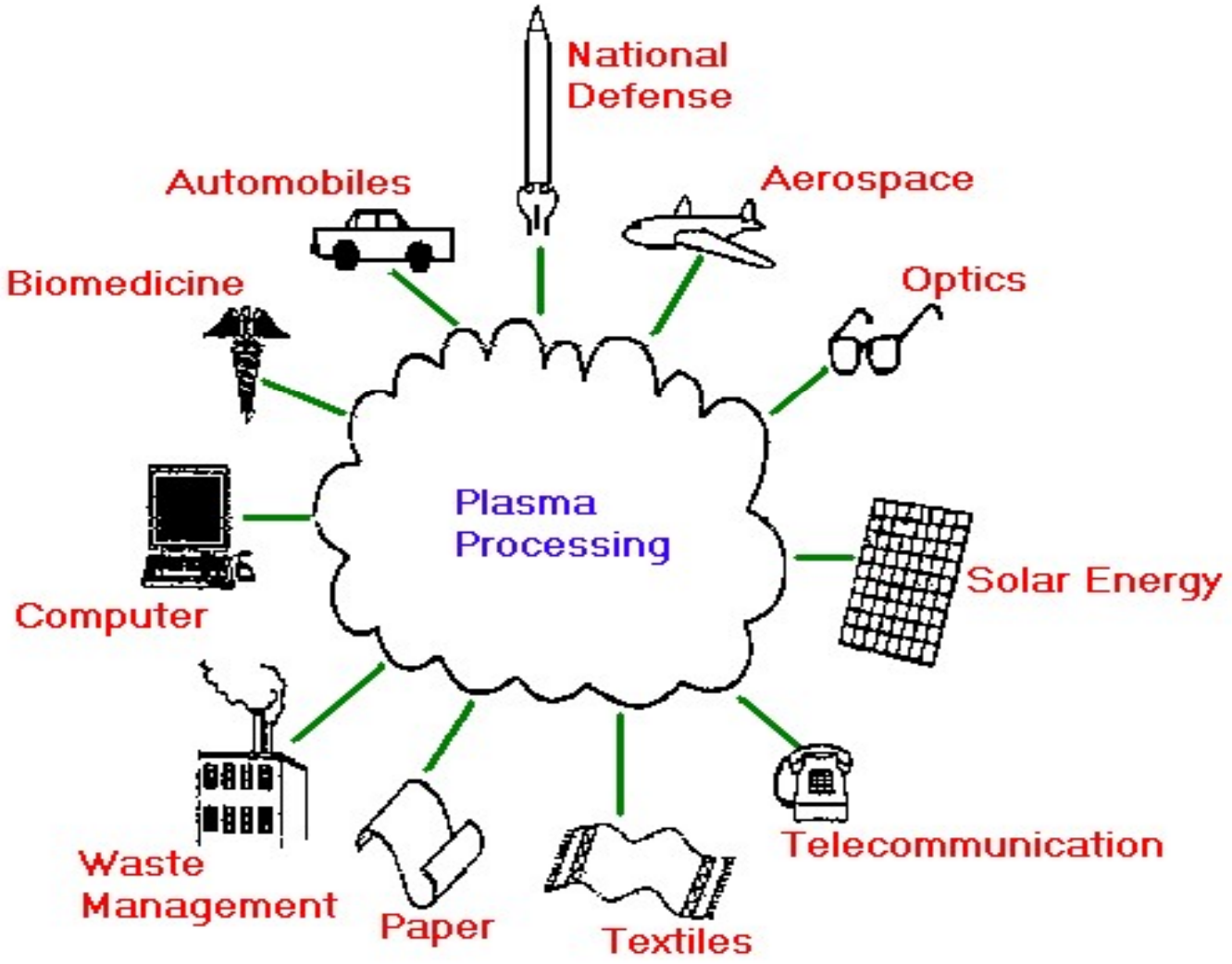



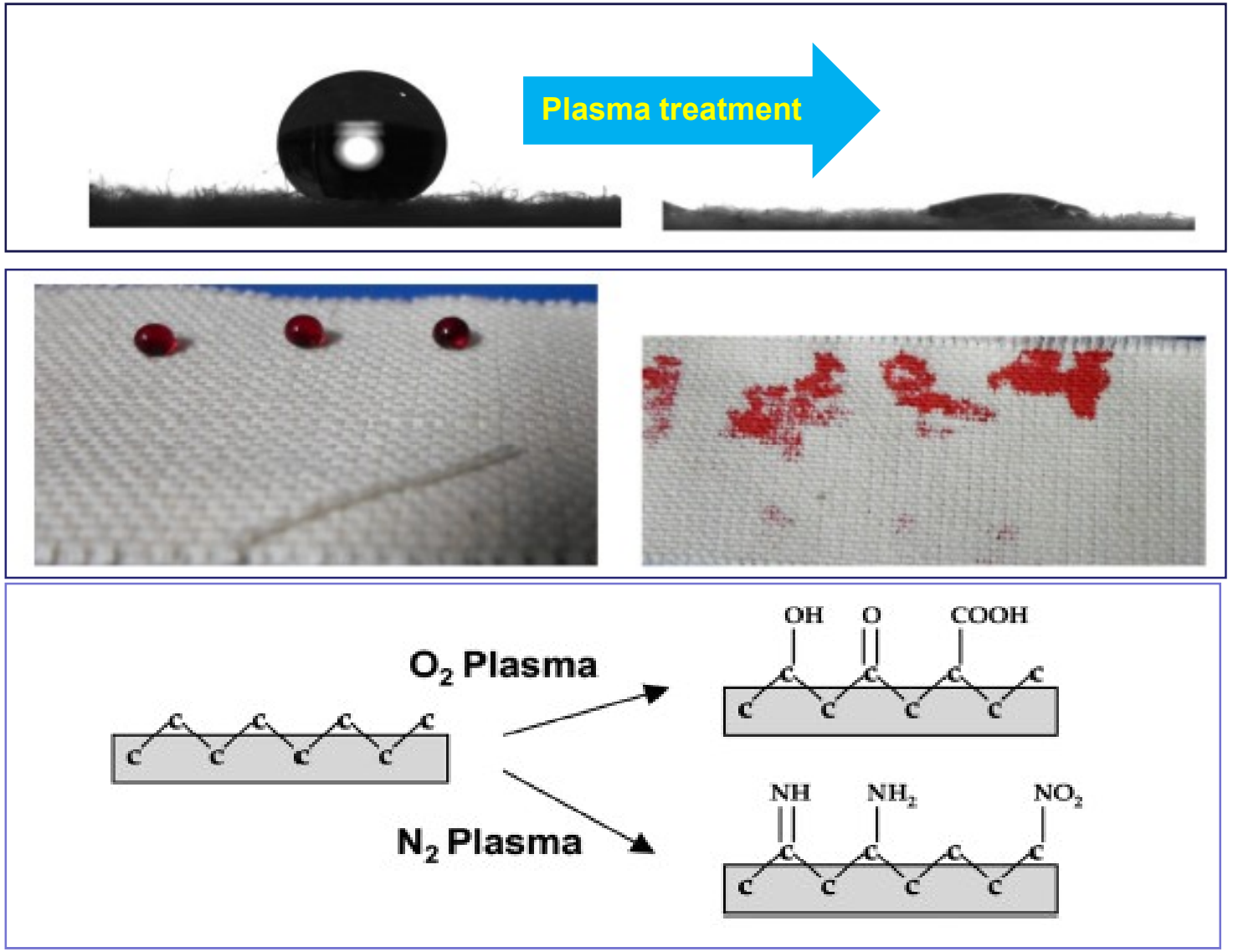

**Axial distance (cm)**

# Plasma Application

# Plasma Processing

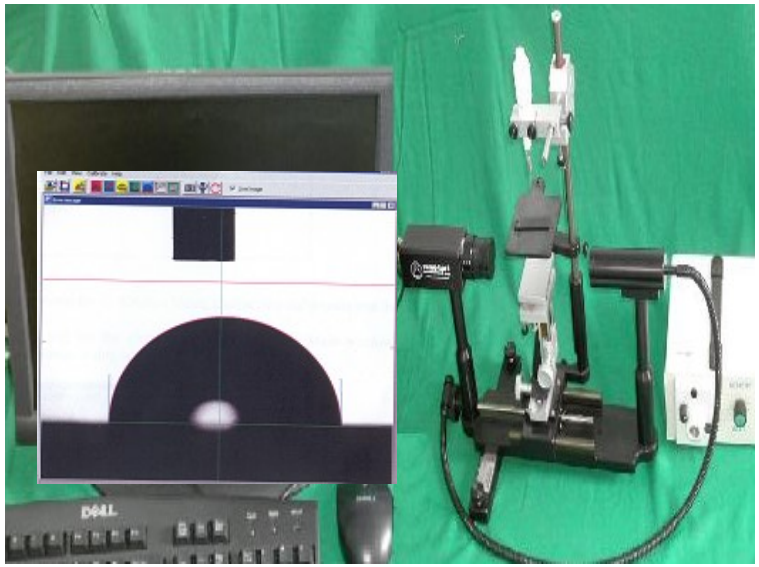


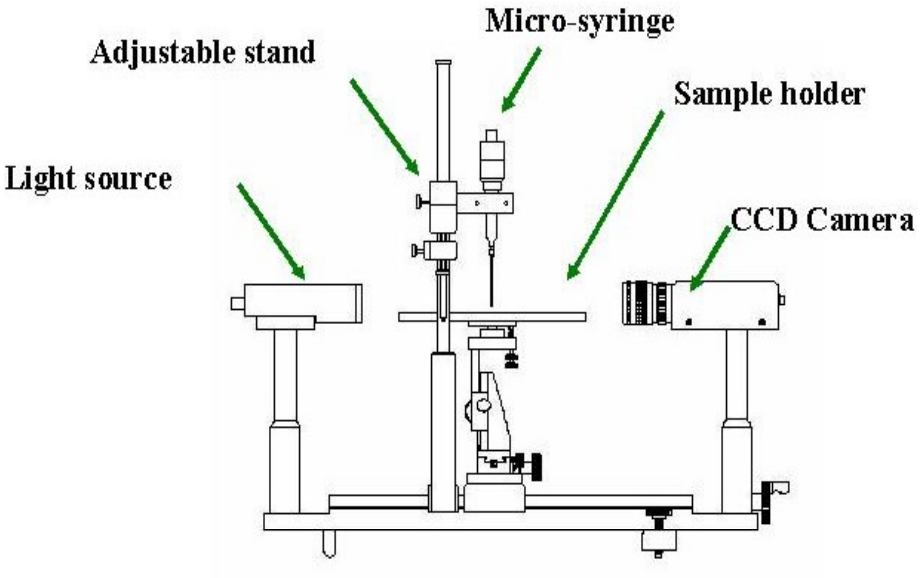
# Plasma Treatment of Cotton




B. Ghimire, D. P. Subedi and R. Khanal, *AIP Advances* **7**, 085213 (2017)

# Surface Characterization of Plasma Treated Solids



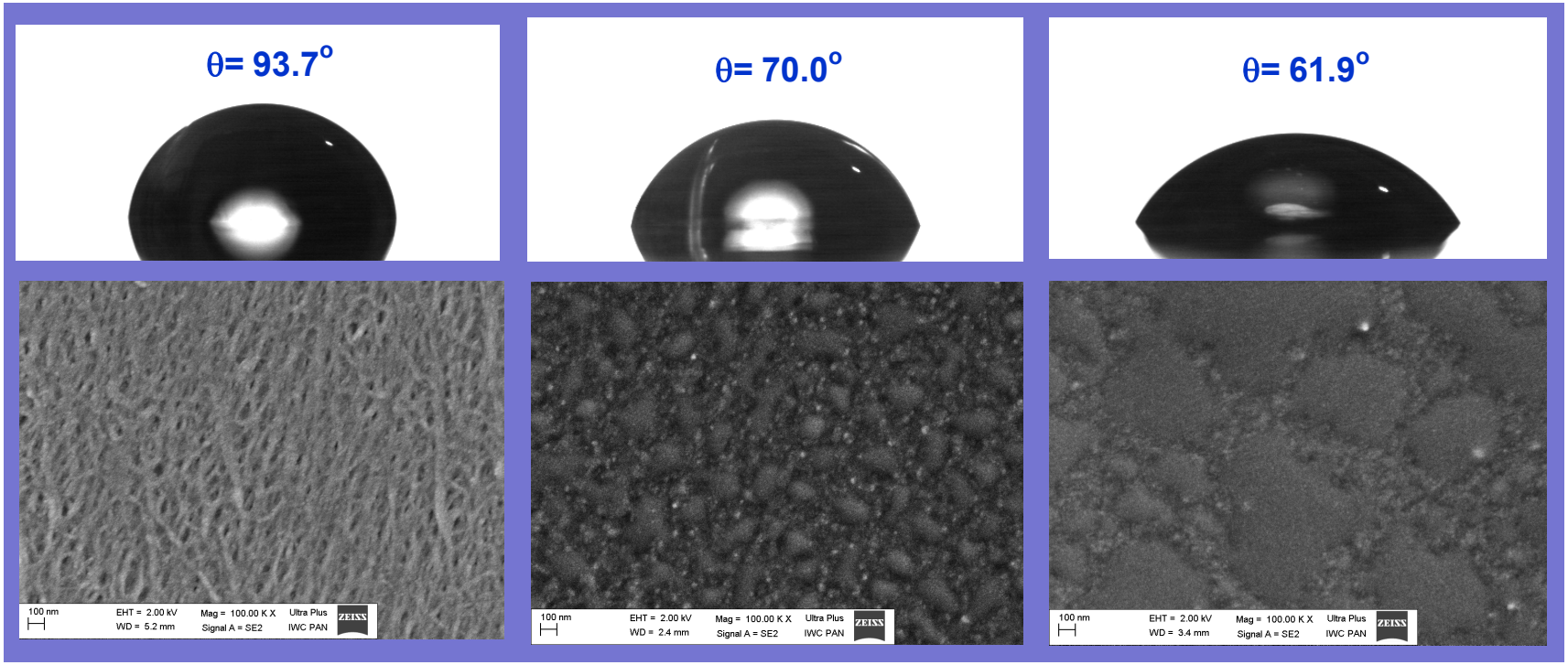



$$\gamma_L(1+\cos\theta)=2(\gamma_L^{LW}\cdot\gamma_S^{LW})^{1/2}+2(\gamma_L^{+}\cdot\gamma_S^{-})^{1/2}+2(\gamma_L^{-}\cdot\gamma_S^{+})^{1/2}$$

| Liquid | Density | Total ($\gamma$) | Disp. ($\gamma^{LW}$) | Polar ($\gamma^{AB}$) | Polar+ ($\gamma^{+}$) | Polar– ($\gamma^{-}$) |
|---|---|---|---|---|---|---|
| Water | 0.9982 | 72.8 | 21.8 | 51.0 | 25.5 | 25.5 |
| Glycerol | 1.0023 | 63.9 | 37.5 | 26.4 | 3.9 | 57.4 |
| Diiodomethane | 3.3250 | 50.8 | 50.8 | 0 | 0 | 0 |

# Sessile Drop and SEM Images of PP

| Untreated | Treated in air plasma | Treated in argon plasma |
|---|---|---|
| θ= 93.7° | θ= 70.0° | θ= 61.9° |



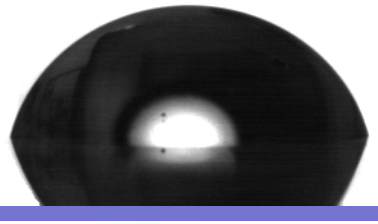

SEM observations of PP film surface before and after the plasma treatment (1 min)

# Sessile Drop and AFM Images of PET

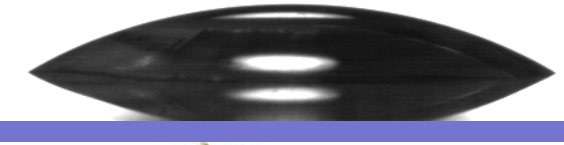
Untreated

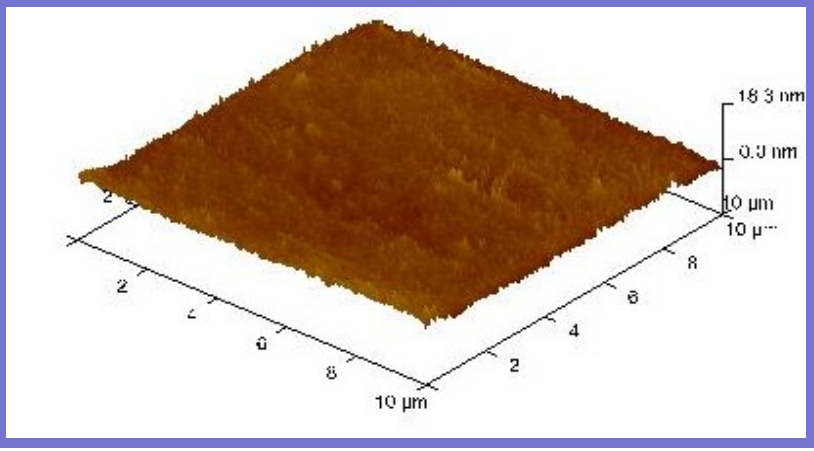
Treated in argon plasma

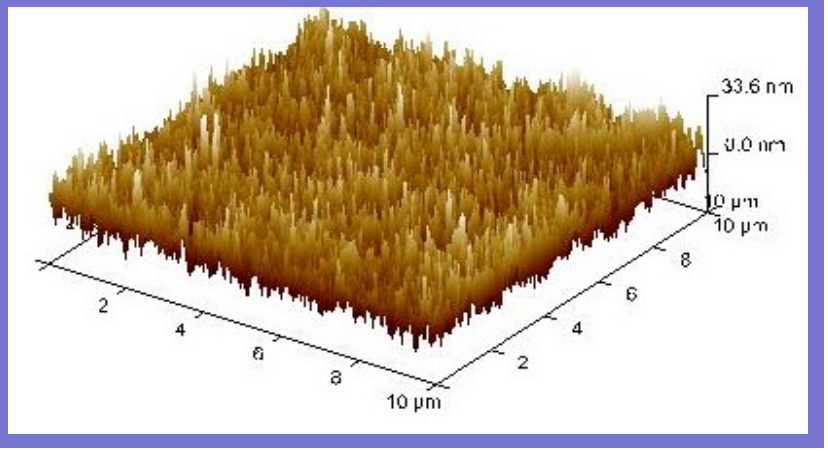
θ= 76.6°



θ= 32.9°





PRAMANA
— journal of
physics

© Indian Academy of Sciences

Vol. 80, No. 3
March 2013
pp. 507–517

# Generation of uniform atmospheric pressure argon glow plasma by dielectric barrier discharge

RAJU BHAI TYATA[1,2], DEEPAK PRASAD SUBEDI[1,*], RAJENDRA SHRESTHA[1] and CHIOW SAN WONG[3]

[1]Department of Natural Science, Kathmandu University, Dhulikhel, Nepal
[2]Department of Electrical Engineering, Khwopa College of Engineering, Libali-2, Bhaktapur, Nepal
[3]Plasma Technology Research Centre, Physics Department, University of Malaya, 50603 Kuala Lumpur, Malaysia
*Corresponding author. E-mail: deepaksubedi2001@yahoo.com

MS received 13 March 2012; revised 8 September 2012; accepted 18 September 2012

# Cost Effective Plasma Technology For Bio-Medical Materials Treatment

C.S. Wong[a*], O.H. Chin[a], S.L. Yap[a], C.C. Tin[a], S.S. Kausik[a], R. Mongkolnavin[b], S. Damrongsakkul[c] and D.P. Subedi[d]

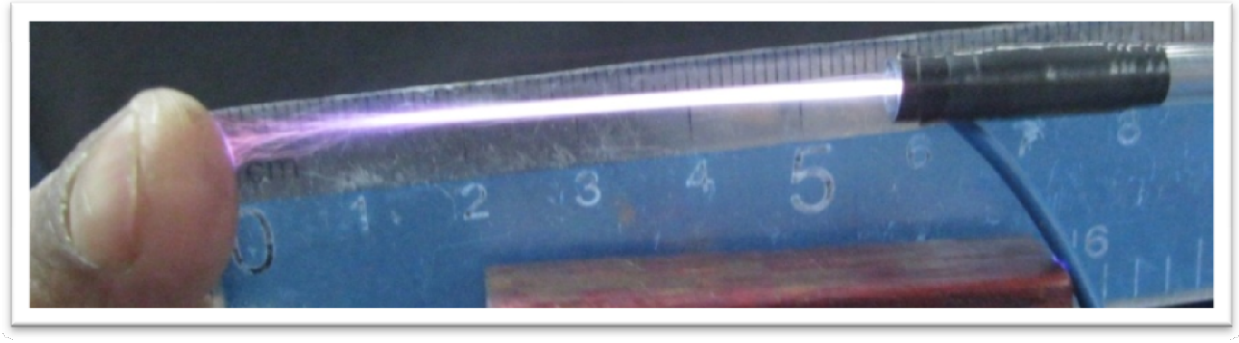
[a]*Plasma Technology Research Centre, Physics Department, University of Malaya, Malaysia*
[b]*Physics Department, Faculty of Science, Chulalongkorn University, Thailand*
[c]*Department of Chemical Engineering, Chulalongkorn University, Thailand*
[d]*Department of Natural Sciences, Science Faculty, Kathmandu University, Dhulikhel, Nepal*
**Email: cswong@um.edu.my*

**Abstract.** In this paper, we summarise the efforts of our group in the development of cost effective plasma devices for applications in the treatment of materials, in particular bio-medical materials.

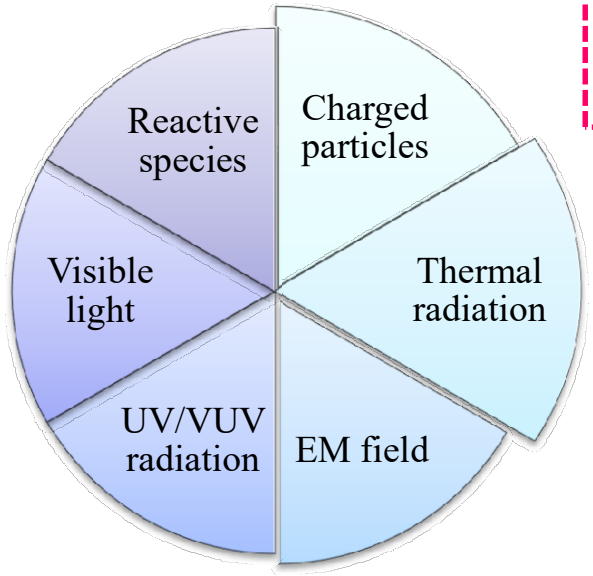
**Keywords:** Plasma devices; bio-medical materials.
**PACS:** 52.8.-s

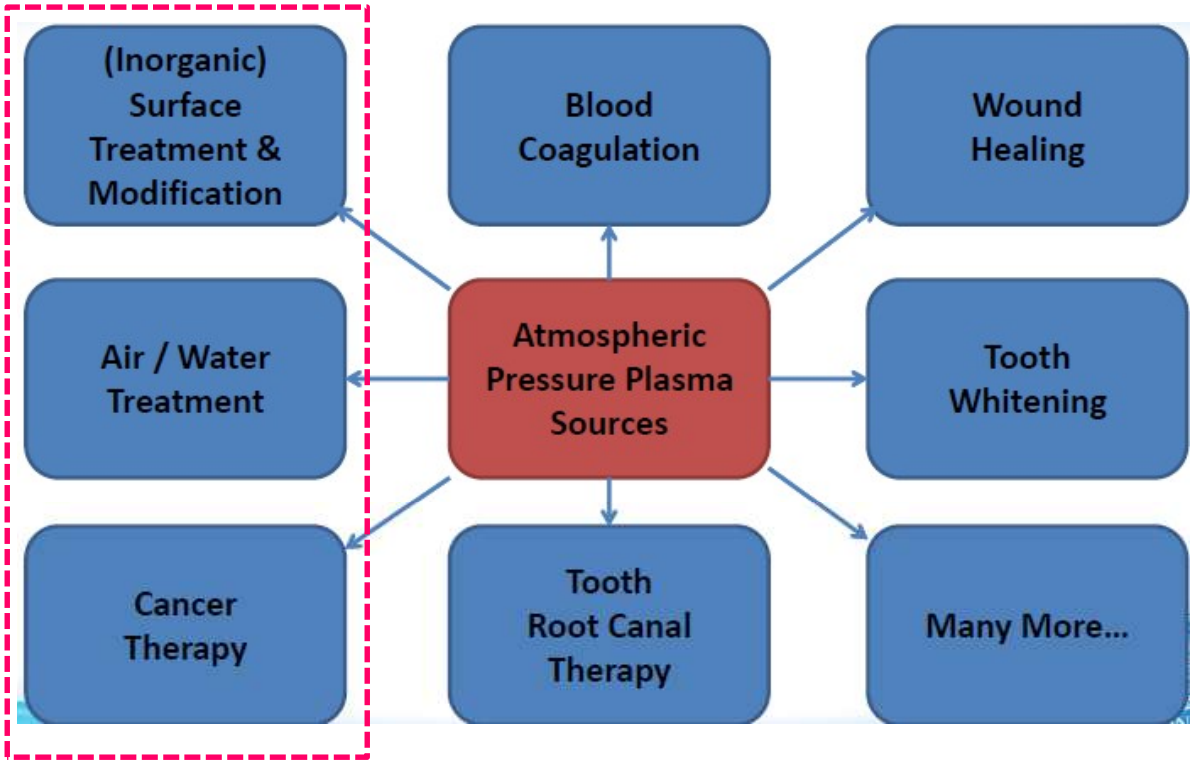
# Plasma Medicine

## Atmospheric Pressure Plasma Jet (APPJ)



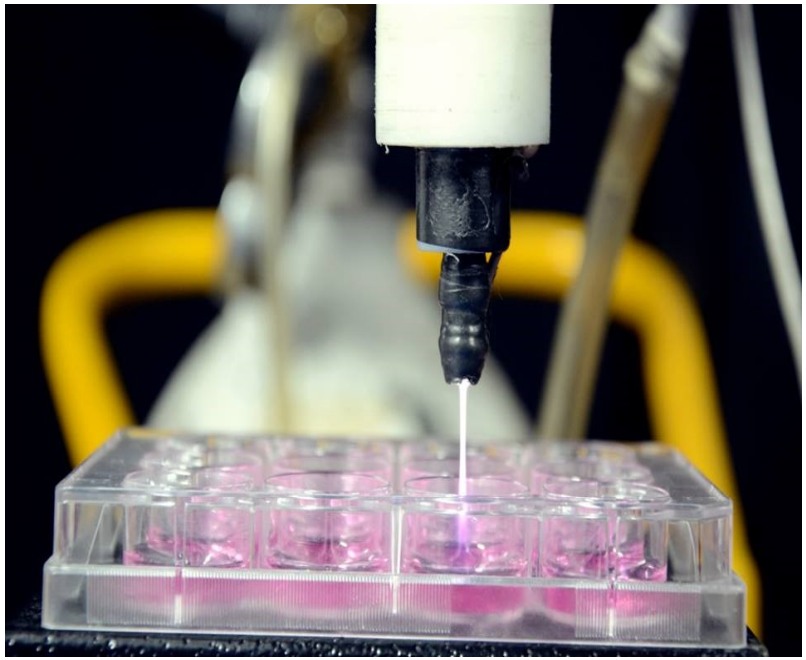
# Plasmas can act as an sterilizer



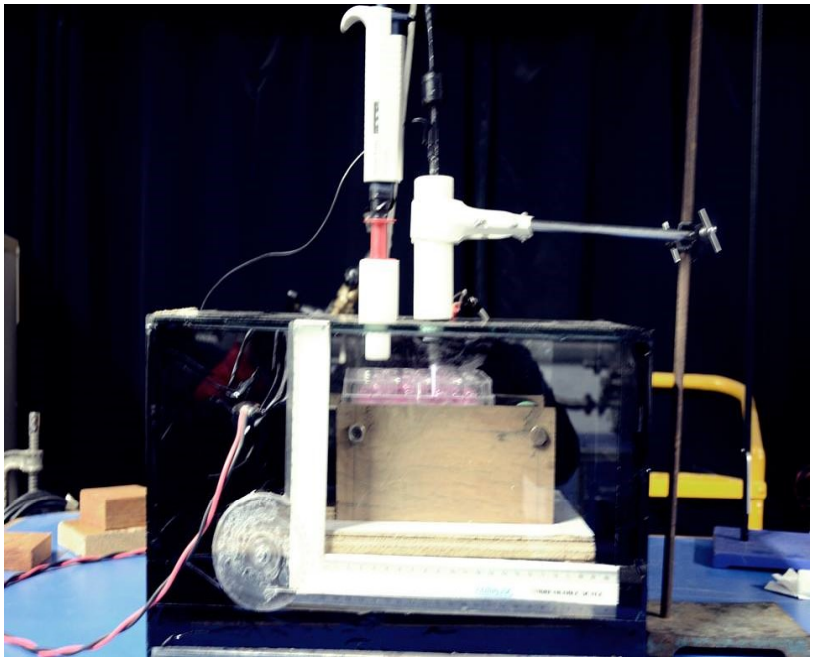




Currently studied area at KU

# Treatment of cells by APPJ



Treatment in cell culture media



Treatment in Breast Cancer

- Cells are grown in 12-well culture plates as recommended in 5% $CO_2$ at 37 $^{o}$C and 95% humidity.

- Cell culture is left out with little medium (100 µl) to prevent desiccation of the sample.

# National and International Research Grants

| Year | Title of the project | Funding source /amount |
|---|---|---|
| 2004 | Study of Refractive index of salt solutions | UGC, Nepal |
| 2007 | Fabrication and characterization of $Al^{3+}/Er^{3+}$ ion doped thin films as anode materials for white light emitting diodes. | Third World Academy of Sciences (TWAS), Italy |
| 2008 | Development of dielectric barrier Discharge unit for the purification of water. | International Foundation for Science (IFS), Sweden |
| 2009 | Eleventh UNESCO workshop on Active Learning in Optics and Photonics, July 11-16, 2009 | UNESCO, France |
| 2010 | Fabrication and characterization of $Al^{3+}/Er^{3+}$ ion doped thin films as anode materials for white light emitting diodes. **(Renewed)** | Third World Academy of Sciences (TWAS), Italy |
| 2011 | Development of dielectric barrier Discharge unit for the purification of water. **(Renewed)** | International Foundation for Science (IFS). Sweden |
| 2011 | 16th UNESCO workshop on Active Learning in Optics and Photonics, Dec 16-21, 2011 | UNESCO, France |

# Output

| No. Students trained in our lab | | |
|---|---|---|
| 1. | Ph. D. | 3 |
| 2. | M. Phil | 7 |
| 3. | M. Sc. | 30 |
| 4. | B. Sc. | 24 |

| Present Status of research students | |
|---|---|
| **Ph. D.** | **3** |
| **M. Phil.** | **3** |
| **M. Sc.** | **2** |

**Research Papers:** More than 30 papers have been published in journal and proceedings.

**Scientific events:** National and international level conferences / workshops in plasma physics and material science have been regularly organized since 2005.

icpsa 2014

# International Conference on Plasma Science and Applications

## 22-24 September 2014

## Kathmandu, Nepal

Organizers:

Asian African Association for Plasma Training (AAAPT)

Department of Natural Sciences, School of Science, Kathmandu University

and

Central Department of Physics

Tribhuvan University, Kirtipur

AAAPT


2005


2007


2006
KATHMANDU UNIVERSITY
ESTD. 1991

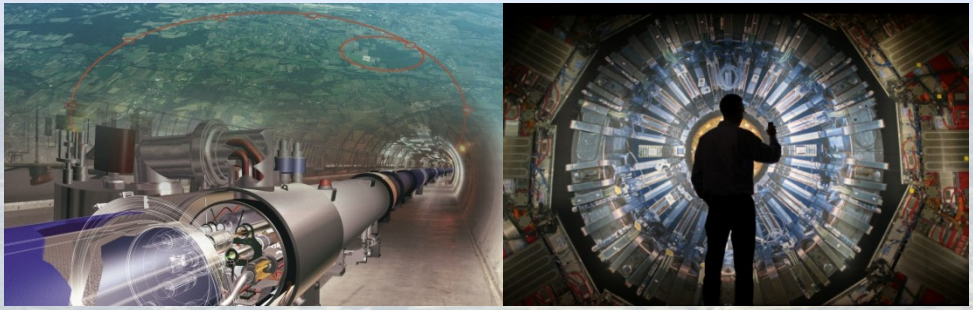

2008
Symposium on Plasma Physics & Material Science

# South Asian High Energy Physics Detector Technology and Applications (*SEPIA*)

## *Kickoff Workshop* *in partnership with* **CERN**

on **20-21 June**

at **Kathmandu University**, Dhulikhel, NEPAL



***International Organizing Committee***

*Charlotte Warakulle (CERN), Emmanuel Tsesmelis (CERN), Archana Sharma (CERN), Suyog Shreshtha (CERN/Ohio), Abha Eli Phoboo*

Scientific Program & Contributions

---

A review of the status, operation of the present facilities, scientific experimental program and upgrades planned for the next few decades at CERN, along with an overview of societal applications of state-of-the-art technologies will be presented. The scientific community of the South Asian member countries are invited to present highlights of their ongoing experimental programs in collaboration with CERN and other scientific international megaprojects. Students from South Asian countries will have the opportunity to present talks and posters. One student each from these countries will be sponsored by CERN.

The two-day program will consist of *invited* plenary and poster sessions.

Workshop website: https://indico.cern.ch/event/625575/

South Asian High Energy Physics Instrumentation

# SAHEPI – 2017

## Workshop
## on
# Detector Technology and Applications

*in partnership with* CERN

June 20 – 21, 2017

Department of Natural Sciences (Physics), Kathmandu University, Dhulikhel, Nepal

# Future Plan

- Identify appropriate research projects of mutual interest at AWAKE / CERN
  - mutual high level visits for further discussion / plan
- Explore opportunities to participate in the AWAKE project
- Express interest and initiate the process to get involved
- Develop capacity in computational plasma physics using the HPC facility recently established in KU with support from CERN

# Thank you !