



Laboratory of Sub-atomic Physics and Cosmology

**Cooperation with Korea on distributed
microwave plasma reactors for surface
processing applications in industry**



Outline

- **CHRONOLOGY OF RELATIONSHIP**
- **PRESENTATION OF LPSC / CRPMN**
 - Plasmas-Materials-Nanostructures Research Center
 - Research axes
- **DMW PLASMAS (Distributed Microwave Plasmas)**
 - Concept of distribution
 - New lines of DMW plasmas
- **CONCLUSIONS ET PERSPECTIVES**

CHRONOLOGY OF RELATIONSHIP

- **VISIT OF A KOREAN DELEGATION TO LPSC** (April 2007)
 - Presentation of research axes of LPSC-CRPMN
 - Visit of LPSC-CRPMN facilities
- **INVITATION TO KOREA BY IPRC** (October 2007)
 - Invited talk to International Plasma Industry Forum
 - Visit of IPRC / Kangwon National University / KAPRA Institute
 - Discussions on academic & industrial cooperations
- **SECOND VISIT OF KOREAN DELEGATION** (October 2008)
 - NDA agreement / Cooperation within the LIA-FKPPL framework ?
 - First discussions on cooperation on hadrontherapy
 - Definition of cooperation program / Plasma etching
- **PARTICIPATION OF LPSC AT FKPPPL WORKSHOP** (February 2009)
- **VISIT IN KOREA** (scheduled in April 2009)

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Plasmas-Materials-Nanostructures Research Center (CRPMN)



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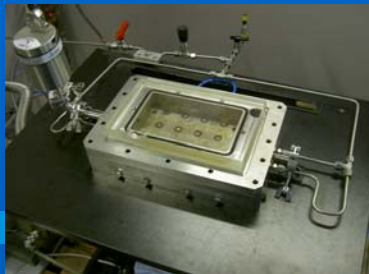
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Website : <http://lpsc.in2p3.fr/crpmn>





Matrix plasma reactor



PBII reactor



Glow discharge tube



PAPVD reactor



Dipolar plasma source reactor



PACVD reactor

STAFF

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Logistic & administrative support of



Research Axes

- **Plasma technologies**
- Plasma-based ion implantation (PBII)
- Plasma assisted CVD (PACVD)
- Plasma assisted sputtering (PAS)
- PAS + PACVD
- Etching

Plasma Technology

- **Distributed microwave plasmas (DMW plasmas)**
- **Micro-discharges**
- **Large area electron sources**
- **Negative ion sources (H^- / D^-) for ITER project**

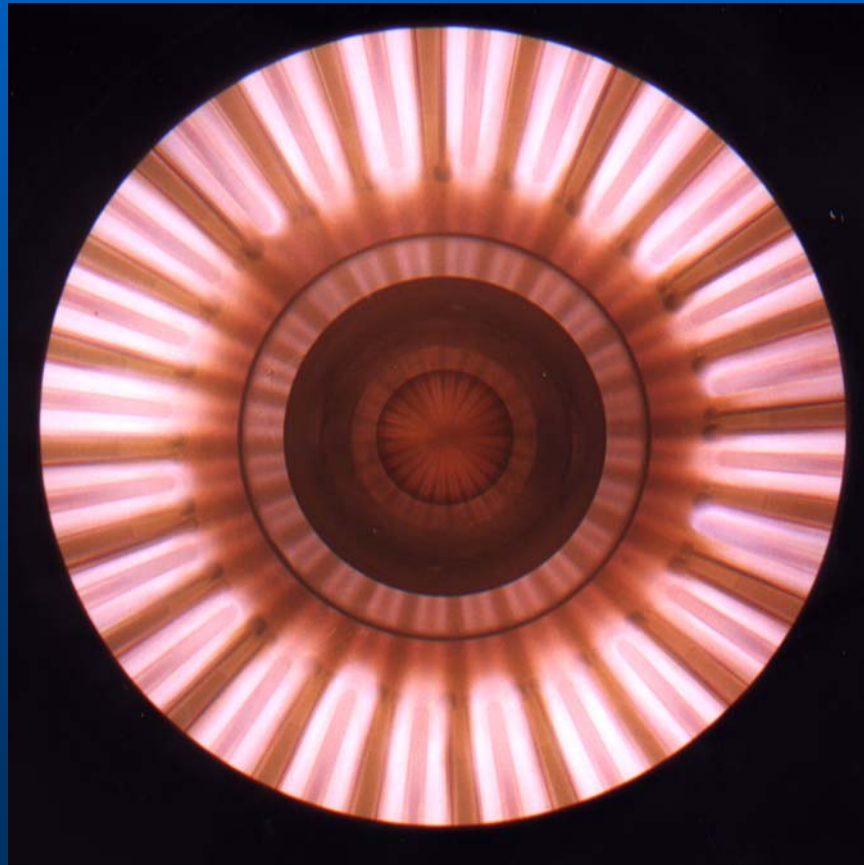
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DECR plasmas

- **Objective : plasma scaling up**
 - Application of a uniform electric field : impossible, except DC
 - **Distribution of elementary sources** on 2-D or 3-D networks
- **New lines of DMW plasmas (distributed microwave plasmas)**
 - DECR Plasmas
 - Multi-dipolar plasmas
 - Matrix plasmas
 - DMW Plasmas with extended operating conditions

DECR plasmas

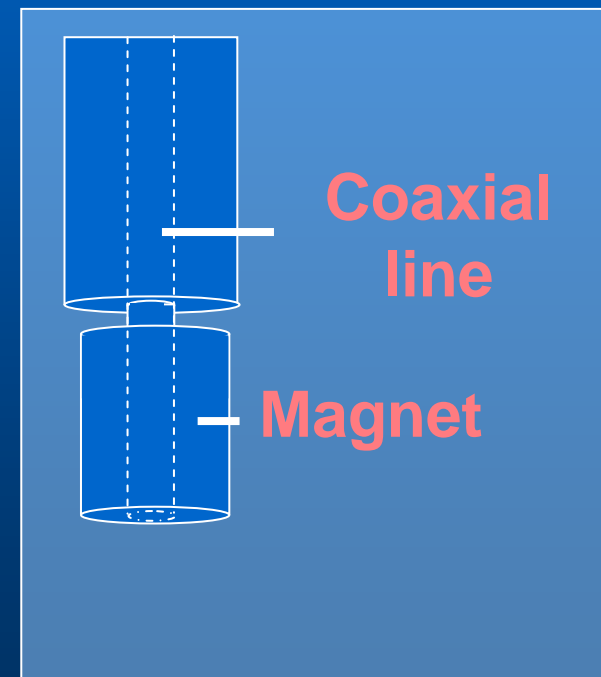


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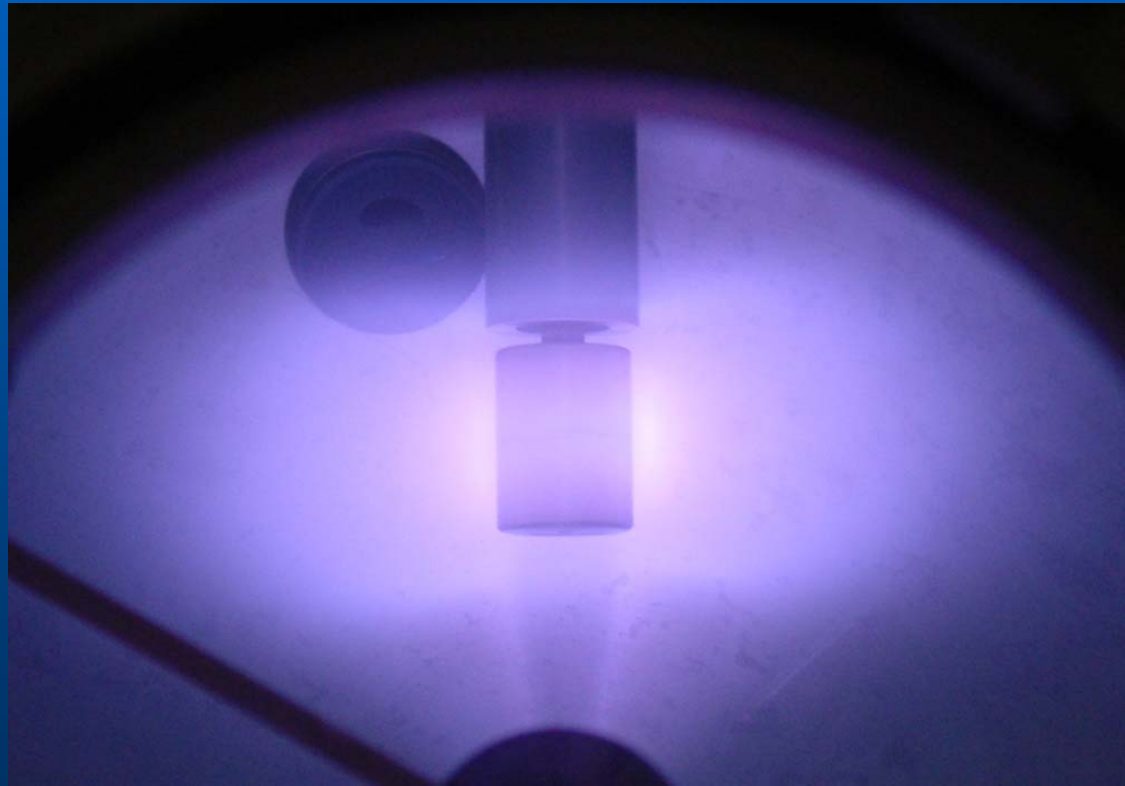
Multi-dipolar Plasma Technology

- Elementary plasma source
- Magnet (magnetic dipole) at the end of a coaxial microwave line
 - ECR
 - Confinement



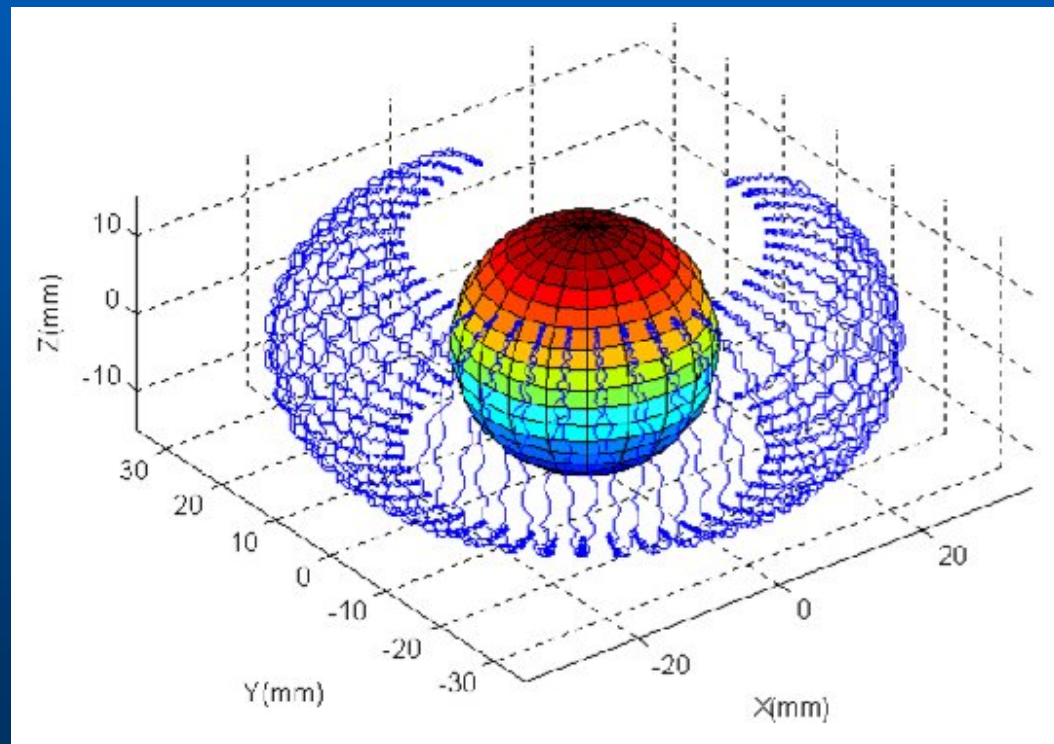
Multi-dipolar Plasma Technology

Elementary
plasma
source



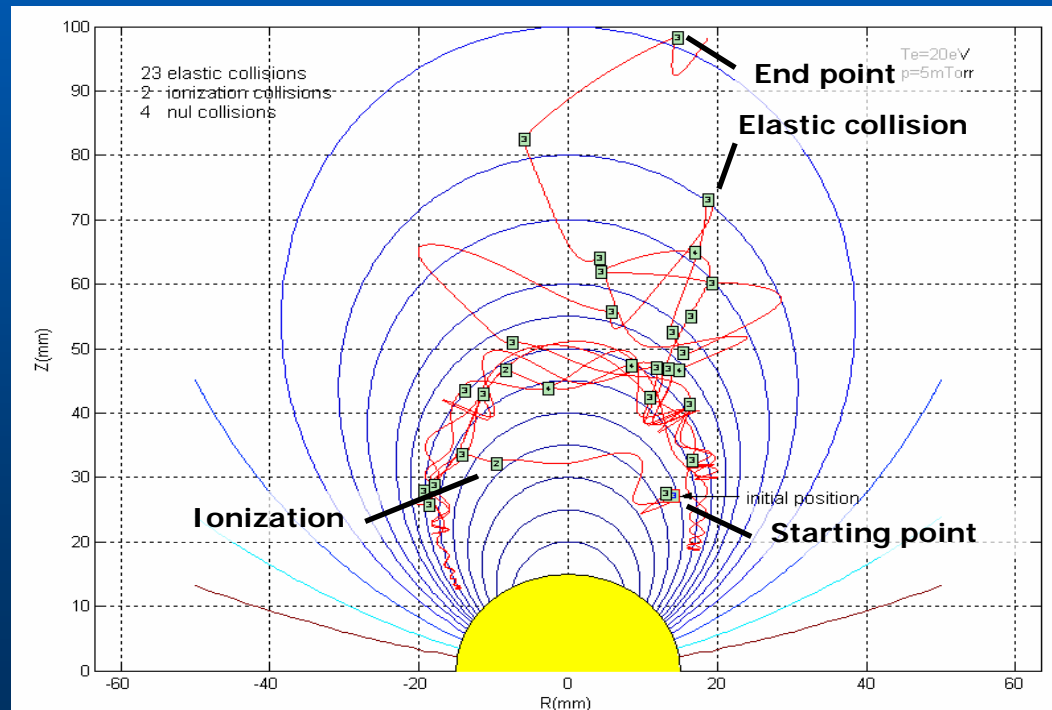
Multi-dipolar Plasma Technology

- Numerical simulation of electron trajectories (without collision)



Plasma Technology

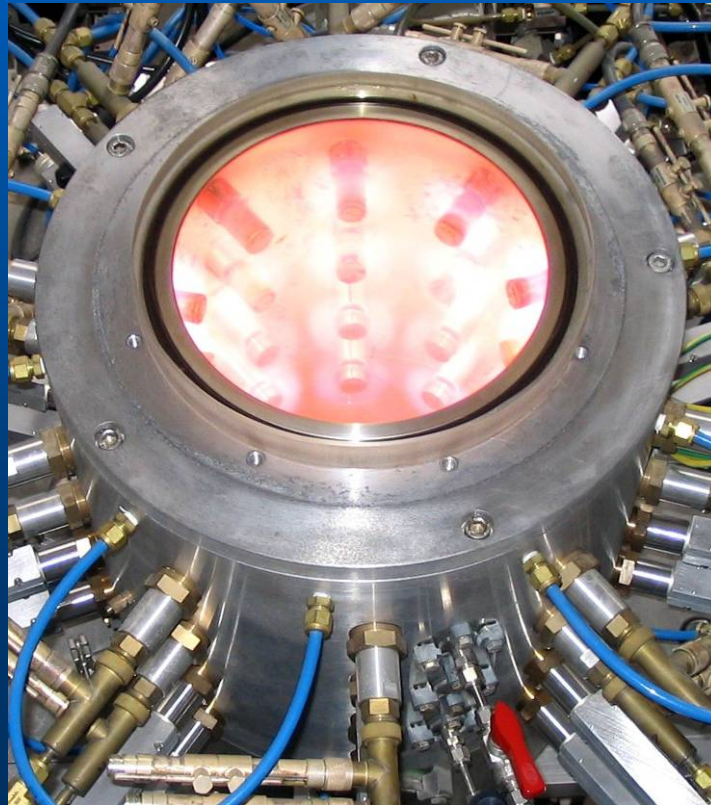
- Numerical simulation of electron trajectories (with elastic and inelastic collisions)



Multi-dipolar Plasma Technology

Cylindrical multi-dipolar plasma

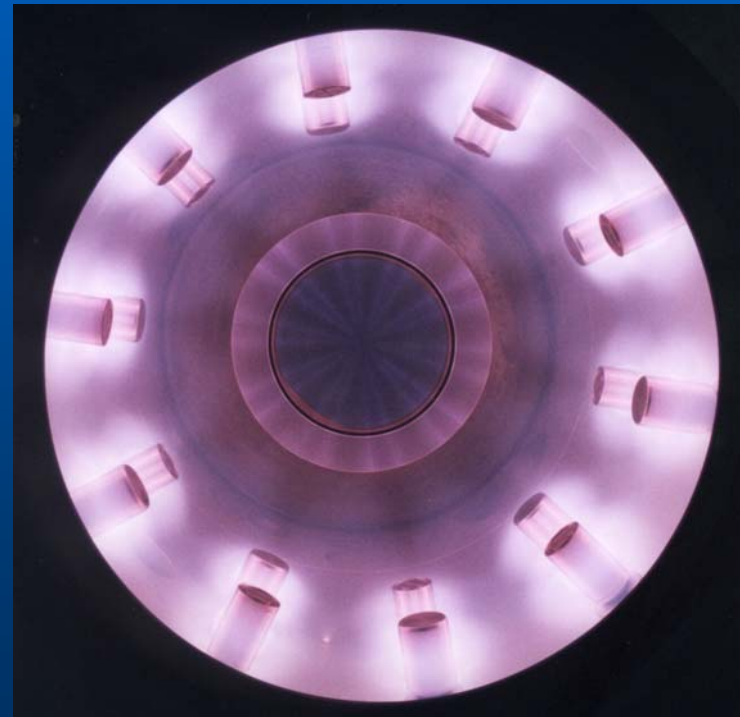
- mtorr range
- up to 10^{12} cm⁻³



Multi-dipolar Plasma Technology

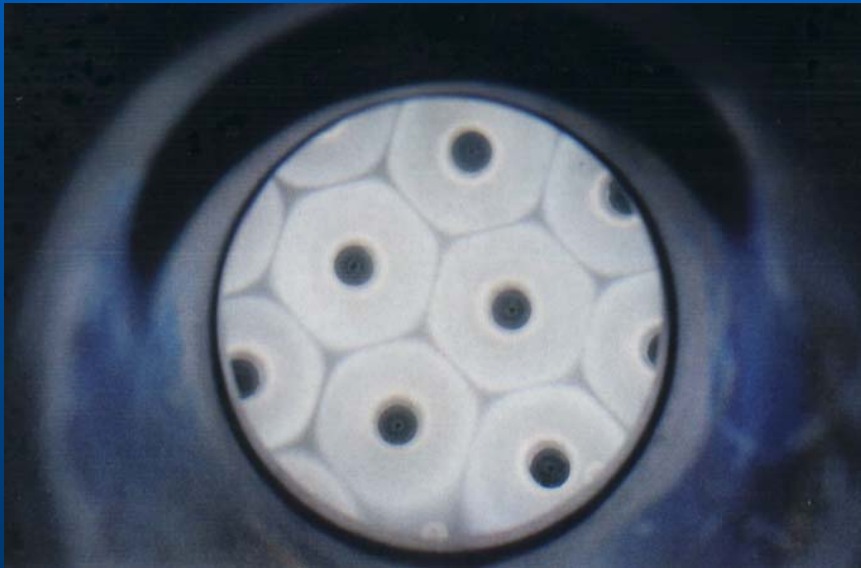
Cylindrical multi-dipolar plasma

- ECR at 2.45 GHz
- mtorr range
- 10^{11} à 10^{12} cm⁻³



Multi-dipolar Plasma technology

Planar multi-dipolar plasma



Oxygen 3×10^{-4} torr

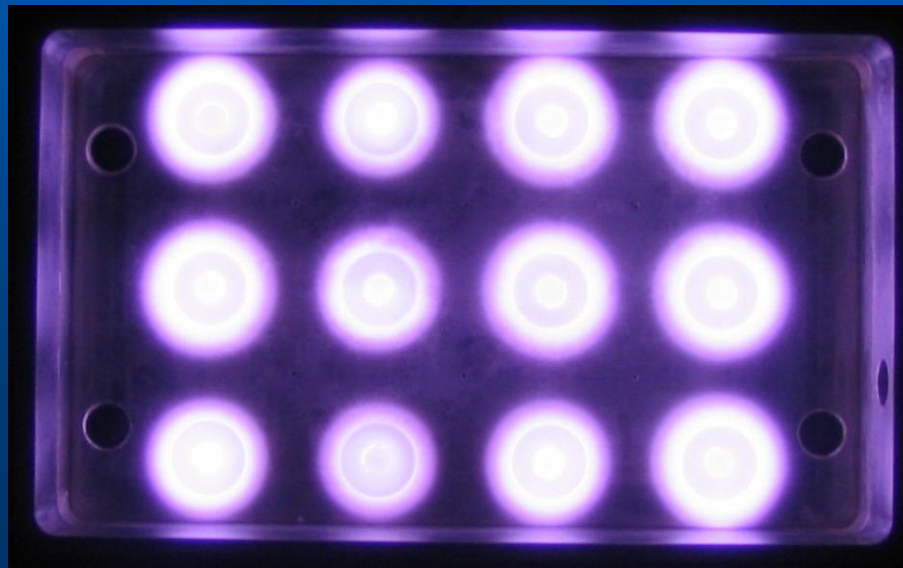


Oxygen 3×10^{-3} torr

Matrix Plasma Technology

Planar matrix plasma

- torr range
- a few 10^{12} cm^{-3}

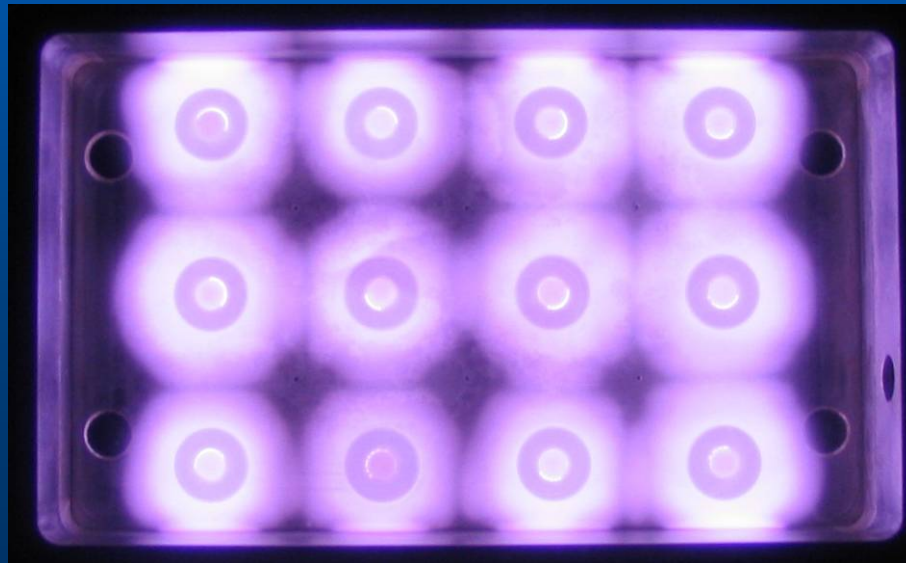


Low microwave power

Matrix Plasma Technology

Planar matrix plasma

- torr range
- a few 10^{12} cm^{-3}

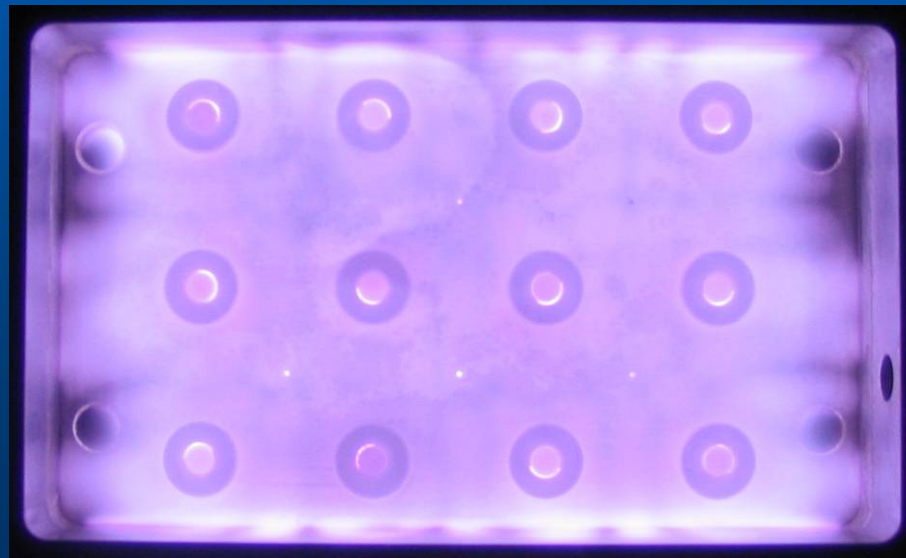


Medium microwave power

Matrix Plasma Technology

Planar matrix plasma

- torr range
- between 10^{12} and 10^{13} cm^{-3}



High microwave power

Conclusions and perspectives

- High flexibility of DMW plasma sources in terms of configuration, operating conditions and processes (combination of processes, duplex processes)
- High reliability as a direct consequence of the application of the distribution concept (low power per elementary source)
- Simplicity
- No physical (or technological) limitation to reactor and process scaling up
- Friendly equipment
- High reproducibility of plasma processes
- Equipments already operative for production at the industrial level (plasma nitriding, PACVD, PAPVD)

Cooperation / Partnership

Present

- **Academic cooperations**

- CNRS network of “Cold Plasmas”

- **Laboratoire International de Technologies et Applications des Plasmas**

- Université de Montréal (plasma sterilization, plasma etching, education)

- INRS Énergie, Matériaux, Télécommunications (ion implantation, plasma etching)

- New Mexico University (PhD co-direction / high-k dielectrics)

- **Industrial Partnerships**

Future

- **Open to scientific cooperations (e.g. PhD co-direction)**

- **Potential partner in scientific partnerships and industrial programs (international programs, european calls, licensing ...)**

Cooperation / Partnership (the end)

Microelectronics / Nanotechnologies

- **Conventional technologies**
 - Protected by world-wide patents / Not available
 - Limitations in terms of operating conditions
 - No breakthrough expected
- **DMW plasmas**
 - Protected by world-wide patents
 - Technologies available for microelectronics
 - Recent technologies with high potential in the near future