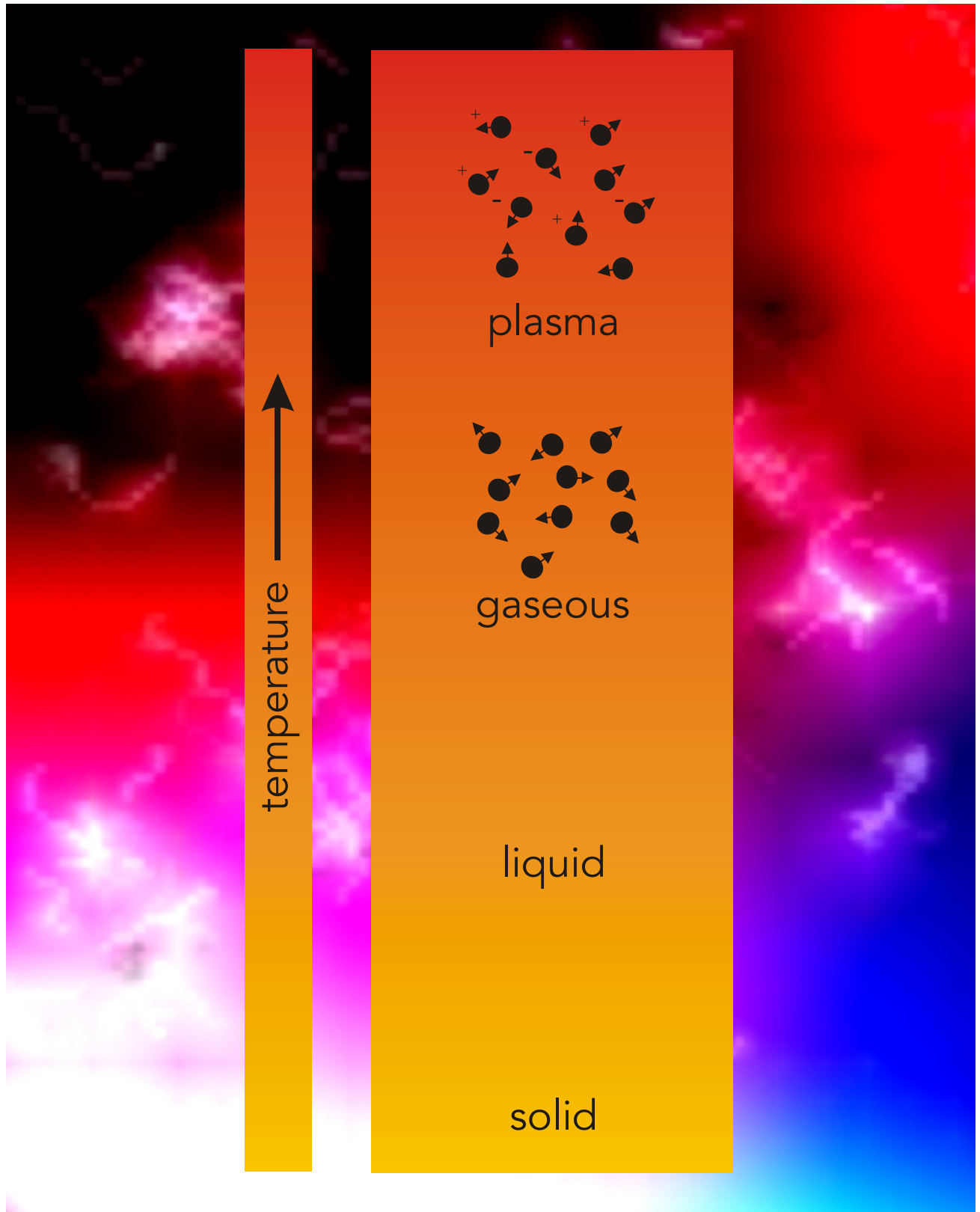


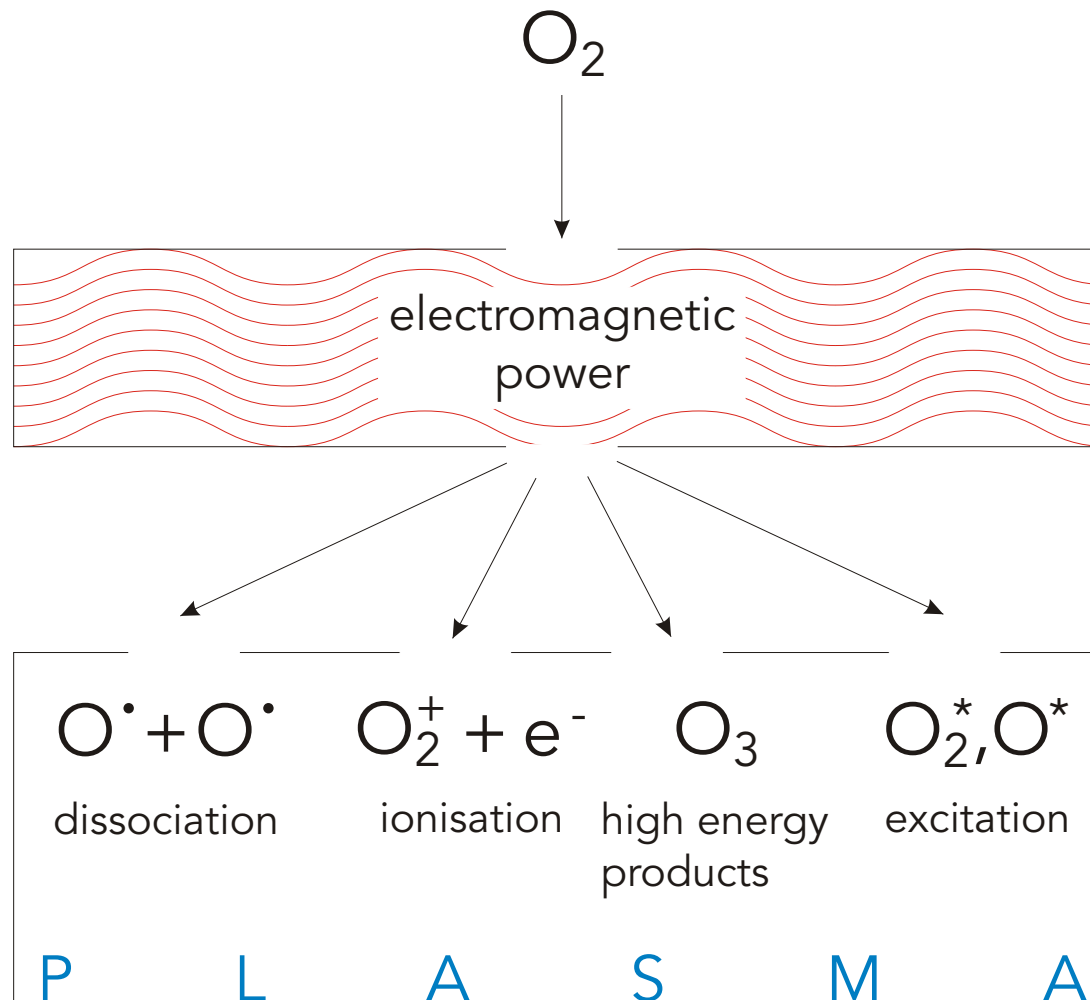
# Plasma, the fourth state of matter



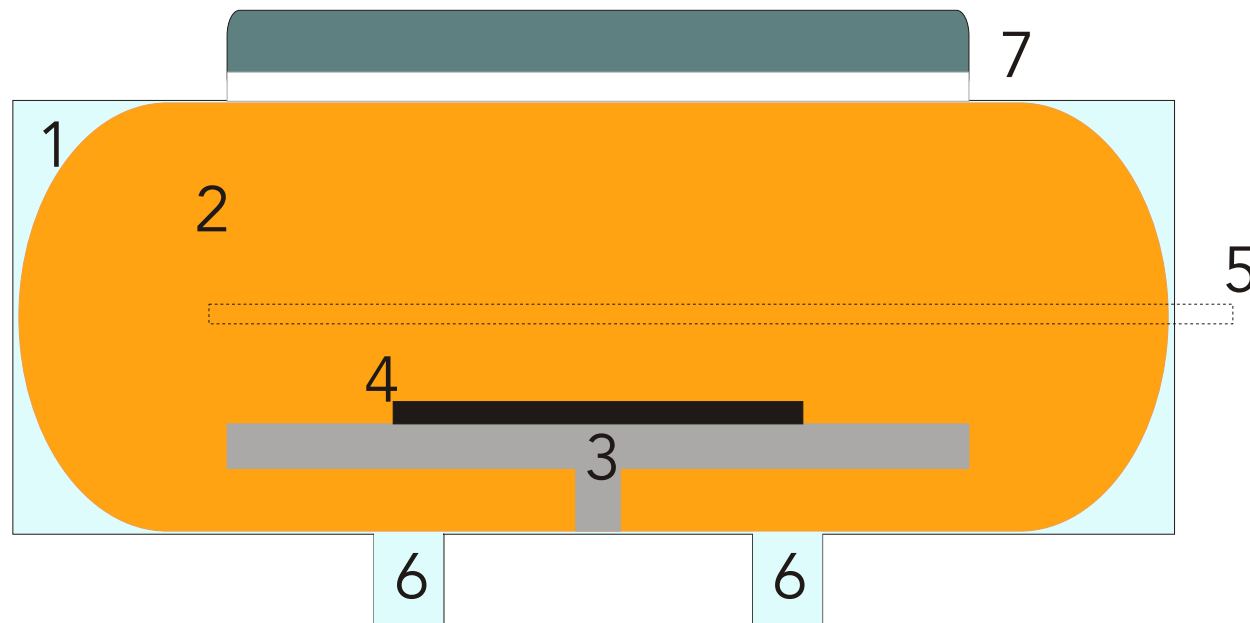
# Natural Plasmas



# Typical processes in a plasma



## Construction of a Low Pressure Plasma System



1: vacuum chamber

3: sample holder

5: gas inlet

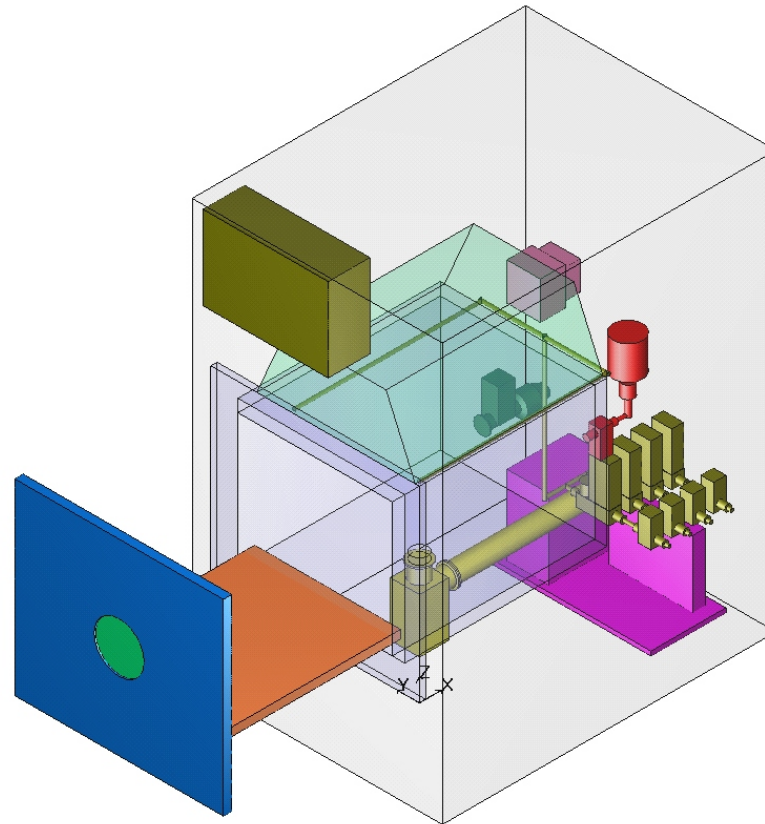
7: microwave generator

2: plasma

4: sample

6: to the pump

# Design of an Low Pressure Plasma Equipment



## Plasma Gases and the resulting specific groups

| specific surface group | suitable gas                                                                                                                   |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| C-F                    | CF <sub>4</sub> , SF <sub>6</sub> , XeF <sub>2</sub> , NF <sub>3</sub> , BF <sub>3</sub> , SOF <sub>2</sub> , SiF <sub>4</sub> |
| C-Cl                   | CCl <sub>4</sub> , BCl <sub>3</sub>                                                                                            |
| C-NH <sub>2</sub>      | NH <sub>3</sub> , N <sub>2</sub> H <sub>4</sub> , N <sub>2</sub> /H <sub>2</sub>                                               |
| C-OH                   | H <sub>2</sub> O, H <sub>2</sub> /O <sub>2</sub> , O <sub>2</sub>                                                              |
| C=O                    | O <sub>2</sub>                                                                                                                 |
| COOH                   | H <sub>2</sub> O, H <sub>2</sub> /O <sub>2</sub> , CO <sub>2</sub> , H <sub>2</sub>                                            |
| C-SH                   | H <sub>2</sub> S, H <sub>2</sub> /S <sub>8</sub> , CS <sub>2</sub>                                                             |

## Comparison between different plasma frequencies

|                                    | Direct current<br>DC               | Radio frequency<br>RF (13,56 MHz)  | Micro wave<br>MW (2,45 GHz)         |
|------------------------------------|------------------------------------|------------------------------------|-------------------------------------|
| Working<br>pressure (Pa)           | 0,1 - 1                            | 10 - 200                           | 10 - 200                            |
| Ion density<br>(cm <sup>-3</sup> ) | 10 <sup>9</sup> (local divergence) | 10 <sup>9</sup> - 10 <sup>10</sup> | 10 <sup>10</sup> - 10 <sup>11</sup> |
| Plasma<br>potential (V)            | >100                               | >100                               | <20                                 |
| Ionization                         | 10 <sup>-7</sup>                   | 10 <sup>-5</sup>                   | 10 <sup>-3</sup>                    |
| Dissoziation                       | low                                | low                                | high                                |

## **Advantages of Microwave Technology over Low Frequency and Radio Frequency Technology**

higher ionisation level

higher electron energy

more formation of radicals

no complex high frequency technology (matching ...)

no electrodes in the chamber (no sputtering effect)

more volume for workpieces

considerable lower temperature loading for workpieces