NADIR

Plasma & Polymers

STYLUS PLASMA NOBLE

an innovative technology for functional coatings deposition on the most heat sensitive materials

Paolo Scopece, Ph.D
Nadir CEO
scopece@nadir-tech.it

WHO WE ARE

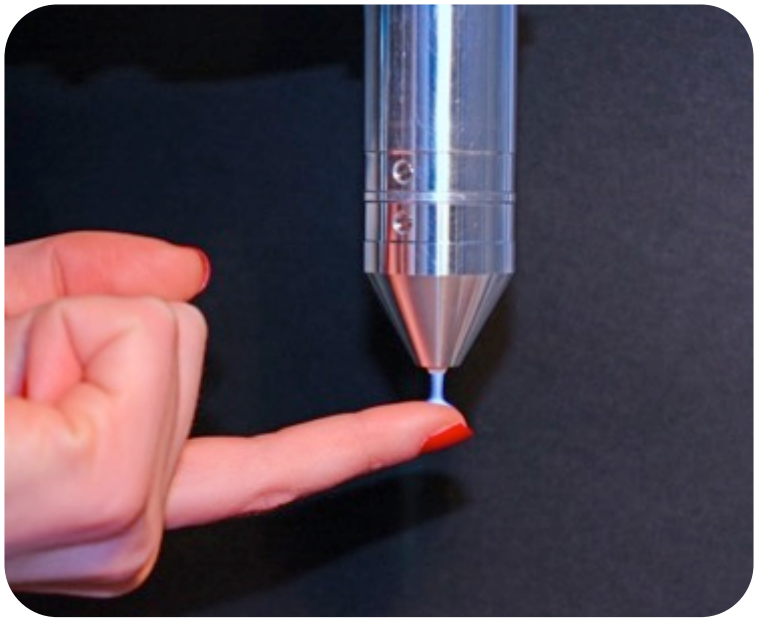
NADIR
Plasma & Polymers

Nadir is an Italian SME, located in Mestre (VE), that focused its activities in the development and applications of an atmospheric plasma device for surface treatment of the most heat sensitive materials.

Plasma Stylus Noble

Cold / Efficient / Clean

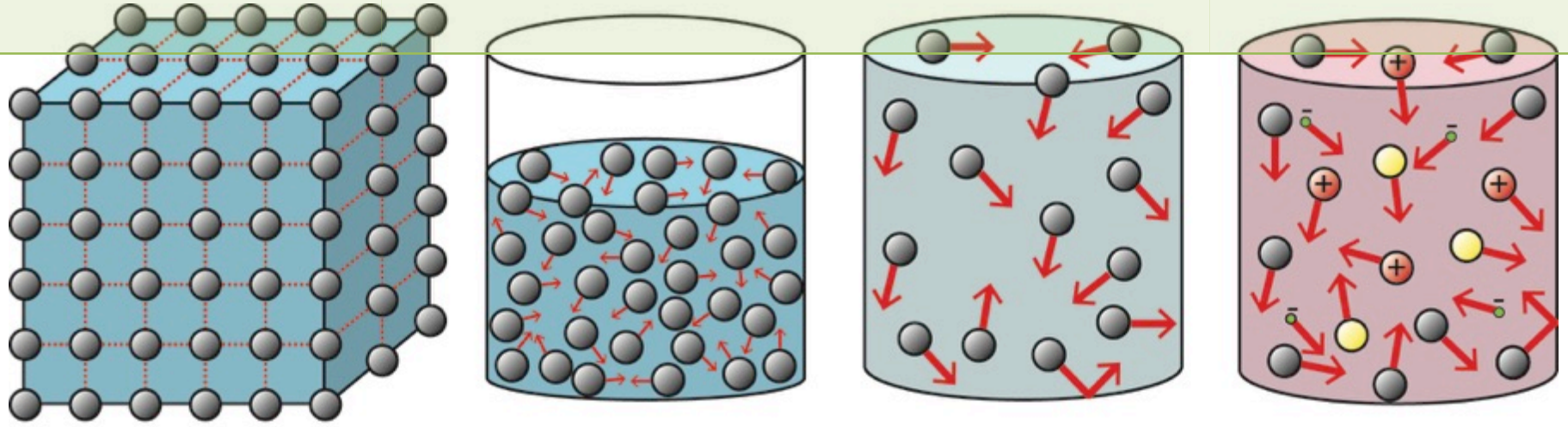
(Patent no. WO2015071746)



What Is Plasma?

NADIR
Plasma & Polymers

Solid	Liquid	Gas	Plasma
• Atoms have a fixed position • There is a chemical bond between atoms	• Atoms or molecules move around • The is a small attraction force between atoms or molecules	• Atoms or molecules moves around and collides • There is no attraction force between atoms or molecules	• Gas that contains free ions and free electrons • **Gas is partially ionized**



Temperature or energy

PLASMA GENERATION

A plasma is created by **applying energy** to a gas

This energy can be:
thermal, or carried by an **electric** current or **electromagnetic** radiations.

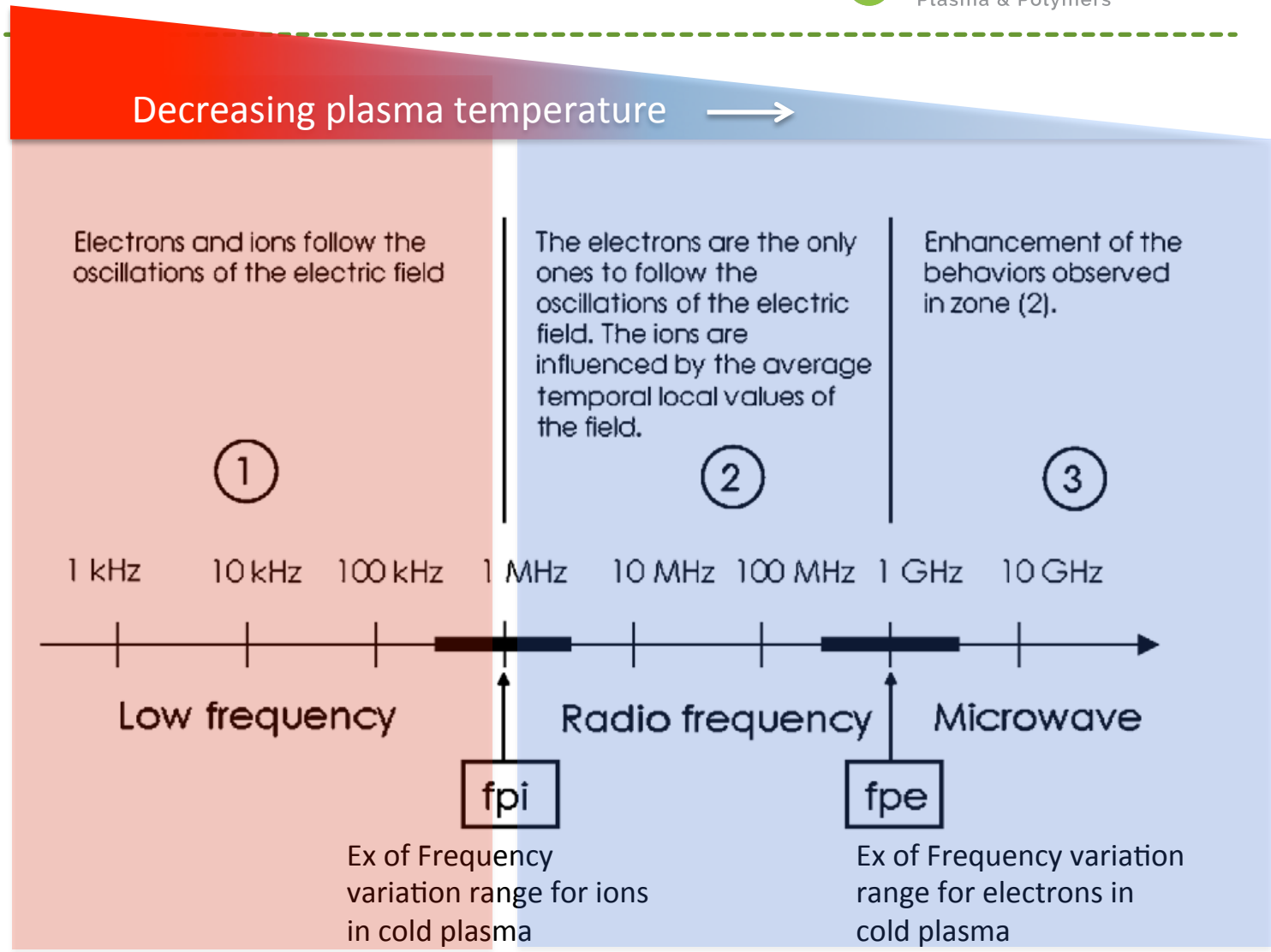
The electric field transmits **energy to the gas electrons**
(which are the most mobile charged species).

This electronic energy is then transmitted **to the neutral species by collisions**

PLASMA GENERATION

Plasma can be ignited by :
DC voltage
Or
AC voltage
at a certain frequency

The **excitation frequency** is important, it influences the behavior of electrons and ions;

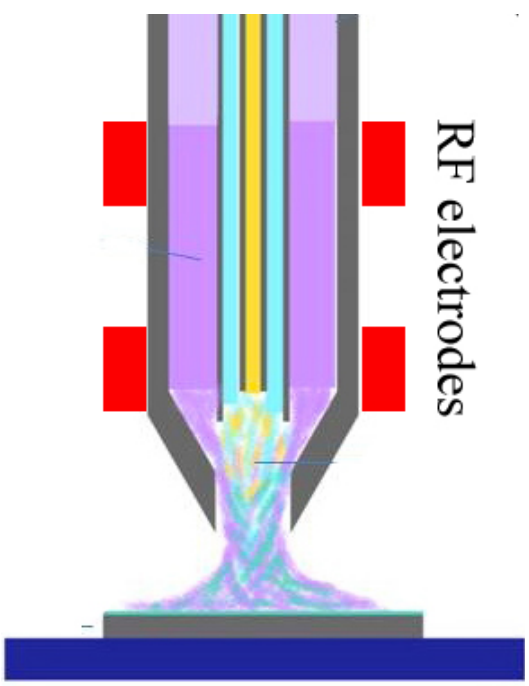


Tendero et al. *Spectrochimica Acta Part B 61 (2006) 2 – 30*

STYLUS PLASMA NOBLE

The Nadir Stylus Plasma is an **atmospheric pressure plasma jet device** that allows the ionisation of a **Noble gas** (Argon) by applying an **high voltage (HV)** nearby the channel where the gas is flowing.

In order to ensure a cold and efficient plasma, the device is also equipped with a **Radio Frequency (27MHz RF) power supply** system that allows the sustain of the plasma in a cold and homogenous way ensuring a **rich plasma of active species:**
free ions, radicals and electrons



PLASMA STYLUS NOBLE – MAIN FEATURES

NADIR
Plasma & Polymers

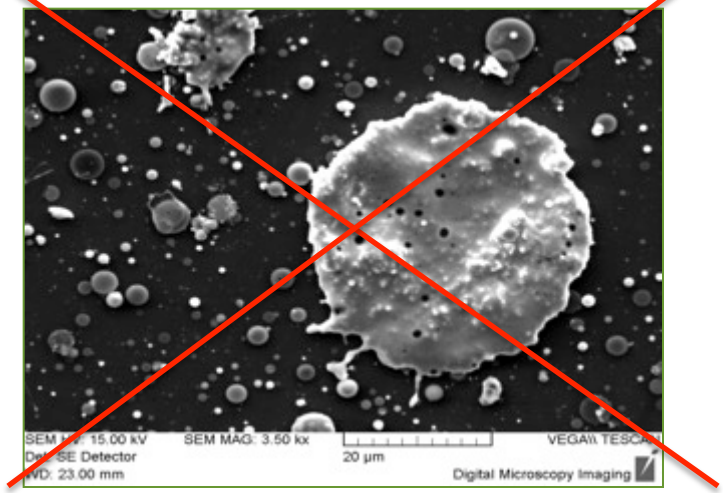
✓ **Double Dielectric Barrier Discharge design**

CLEAN

- ✧ Avoids streamers to arc transition
- ✧ Avoids the contact between the plasma and the electrodes
- ✧ Avoids the problem of the electrodes erosion
- ✧ Ensures a clean plasma

Common problem of arc discharge torches is here avoided

NO SURFACE POISONING



PLASMA STYLUS NOBLE – MAIN FEATURES

NADIR
Plasma & Polymers

✓ **It combines a HV-HF power supply (3-10W) with a RF power supply (10-80W)**

- ✧ Ensures a low temperature plasma
- ✧ Ensures low current carrying streamers
- ✧ Ensure high energy transfer to electrons
- ✧ Ensure high efficiency plasma treatments

COLD

SURFACE TREATMENT < 40°C

The low temperature allows to not heat the treated surfaces and therefore to not damage or induce surface expansion or phase changes

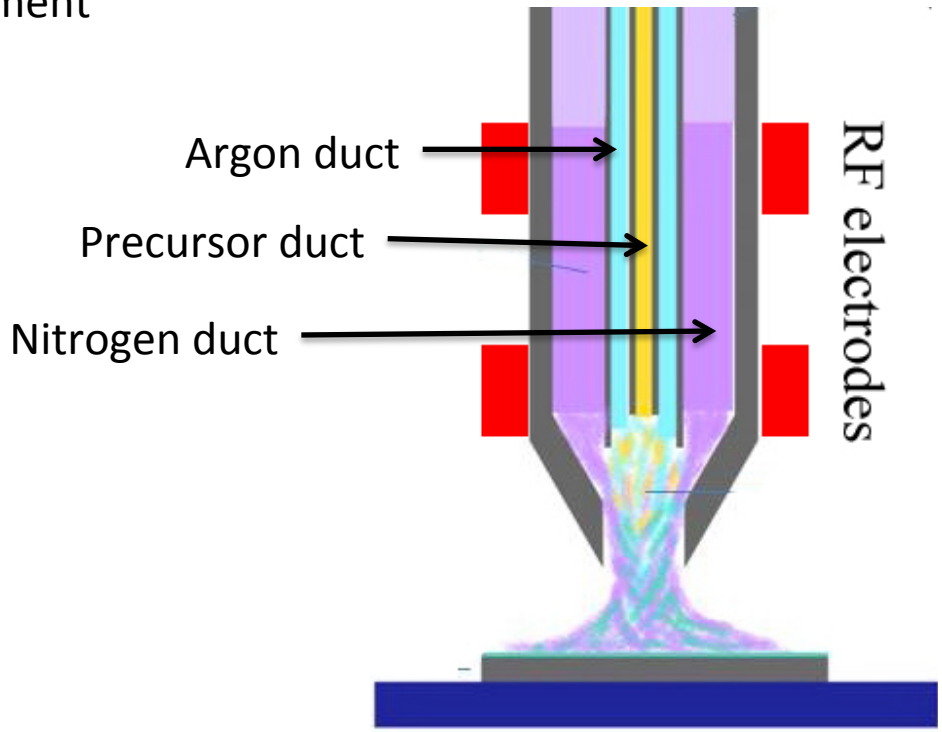
PLASMA STYLUS NOBLE – MAIN FEATURES

NADIR
Plasma & Polymers

EFFICIENT

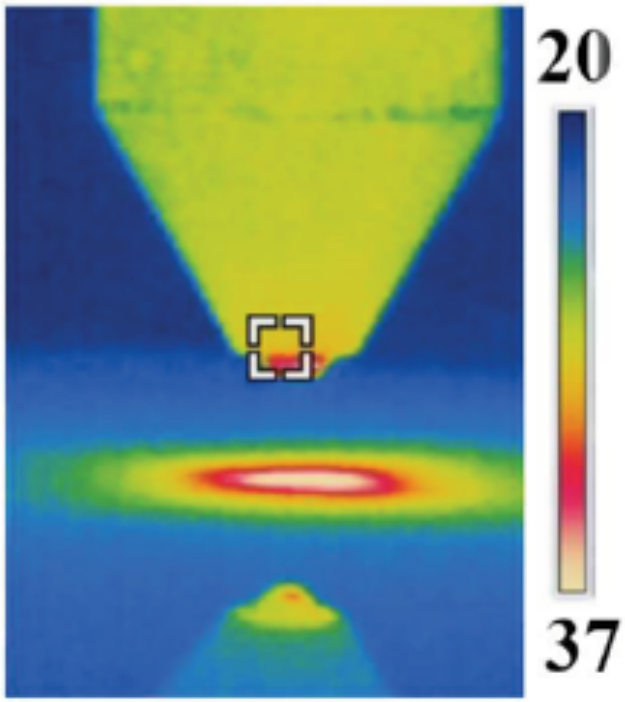
- ✓ **Multiple coaxial design for**
  - ✧ Working gas
  - ✧ Chemical percursors introduction (vapours or aerosols)
  - ✧ Environmental atmosphere confinement

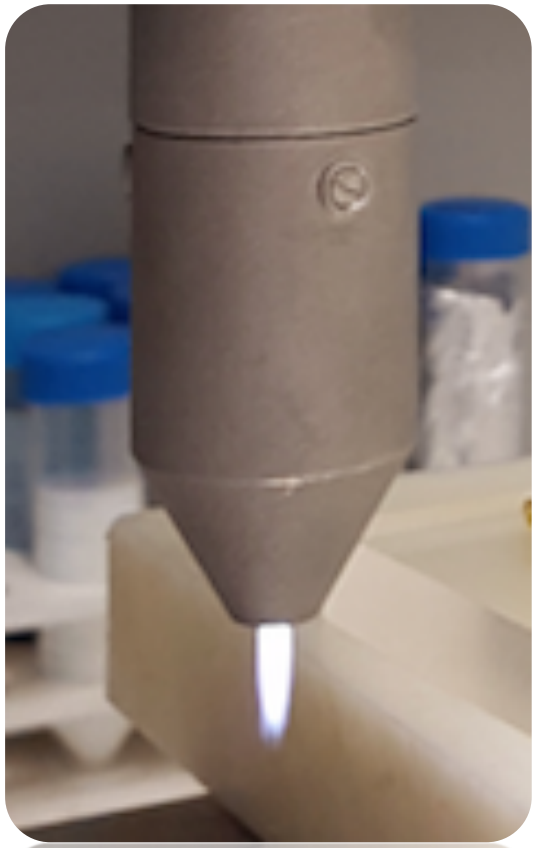
SURFACE CHEMICAL
FUNCTIONALISATION
AND
COATING DEPOSITION



PLASMA STYLUS NOBLE – MAIN FEATURES

US Grant n. 9693441B2



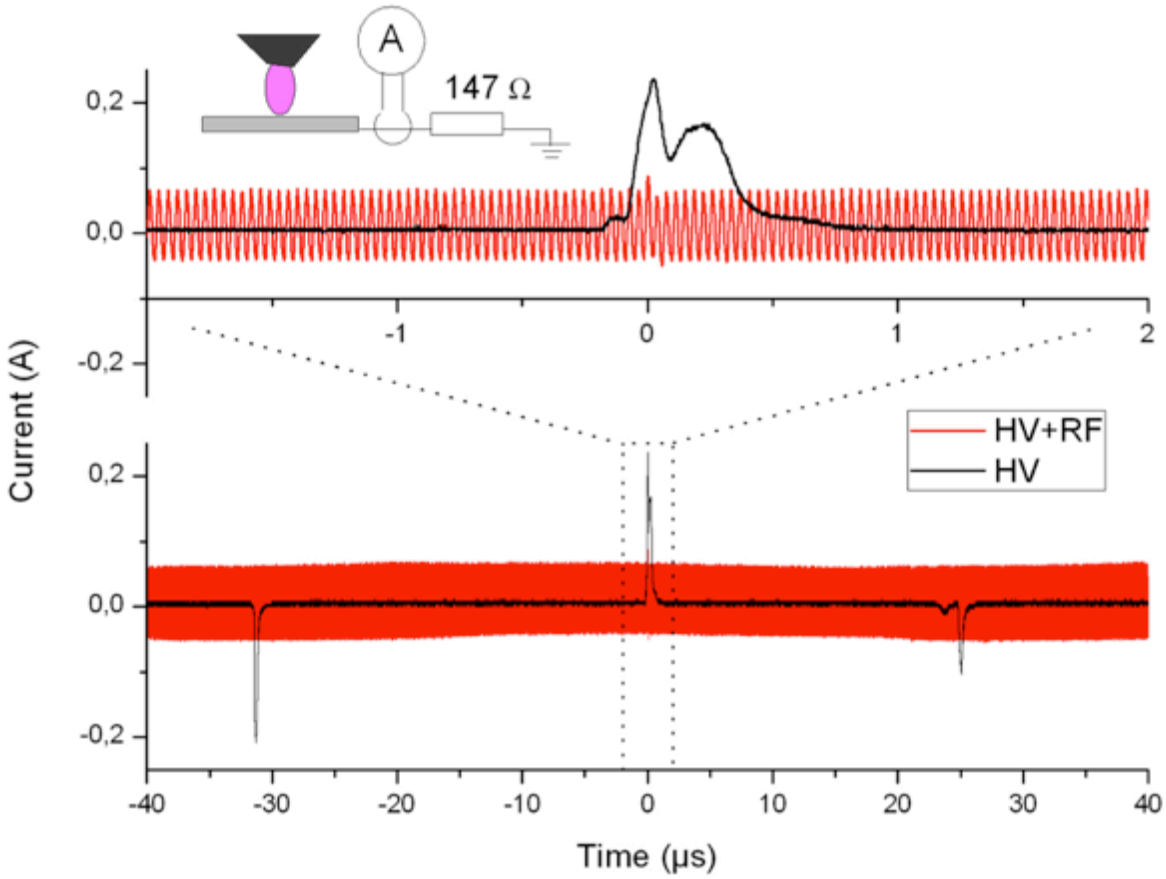


PLASMA STYLUS NOBLE – HOW IT WORKS

NADIR Plasma & Polymers

UNIVERSITÀ DEGLI STUDI DI PADOVA

✓ **Dual frequency coupling**

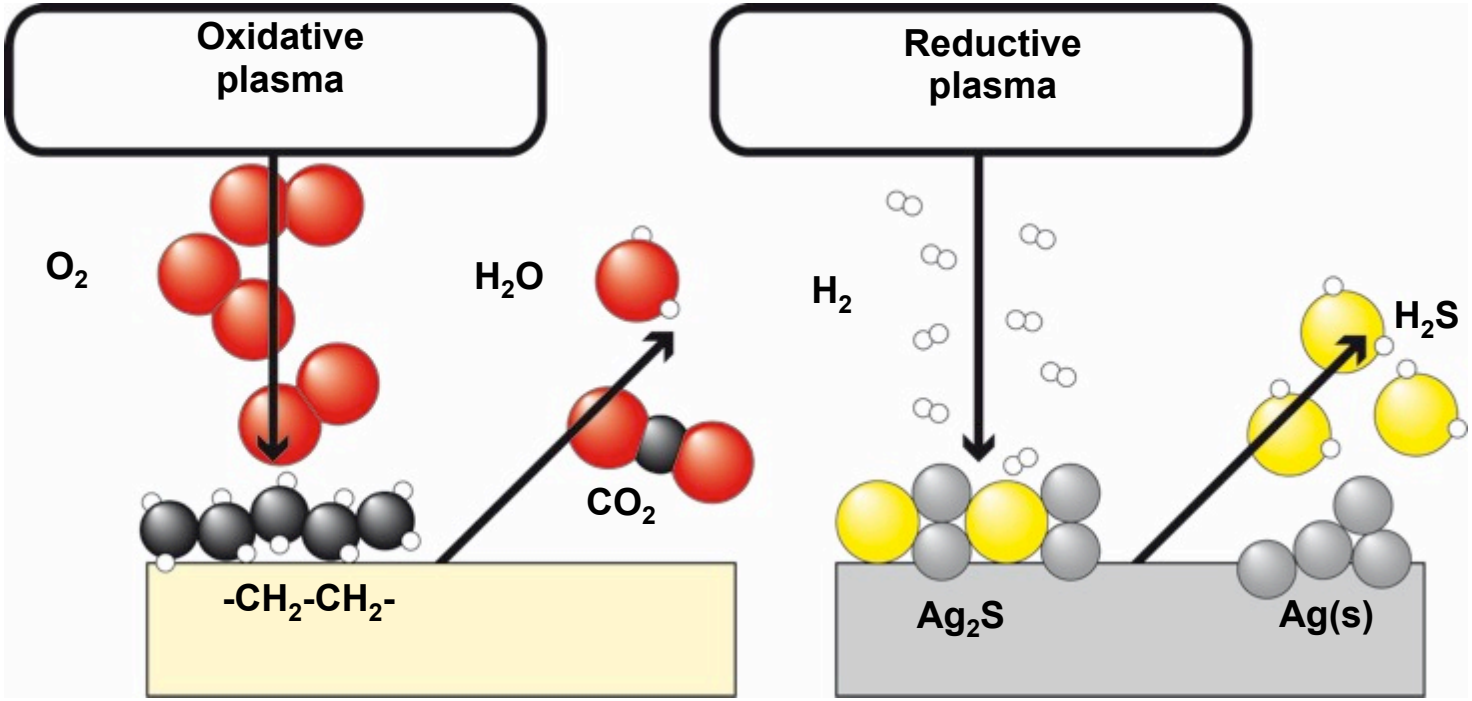


When RF power is overlapped to HV 16 kHz plasma,
a continuos AC 27 MHz current can be detected (on metallic samples)
and
High current kHz streamers (> 100 mA) are avoided.

STYLUS PLASMA NOBLE – CLEANING APPLICATIONS

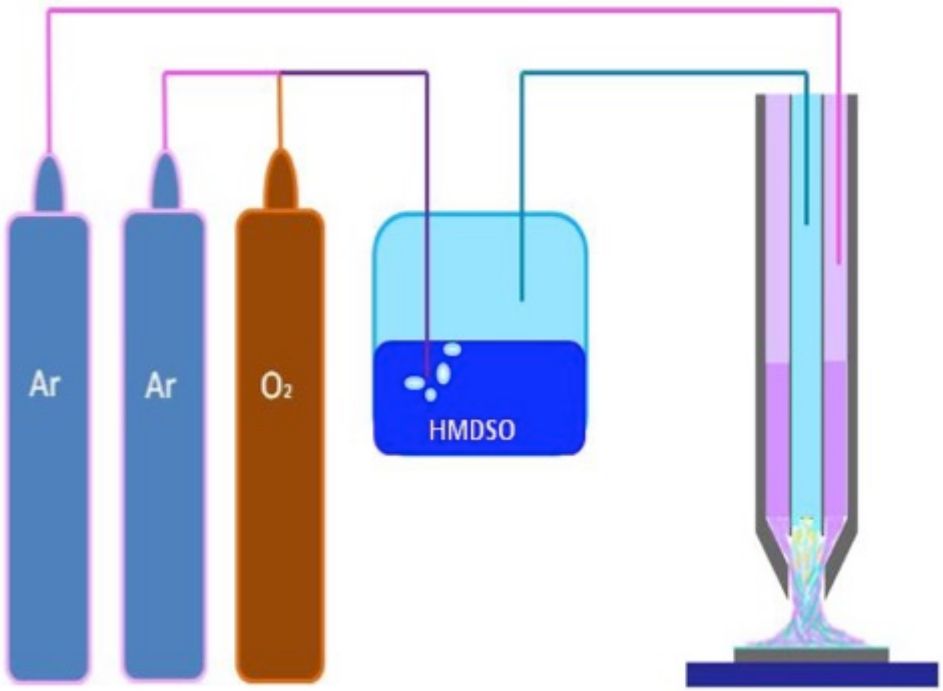
It allows to work with different Argon gas mixtures:

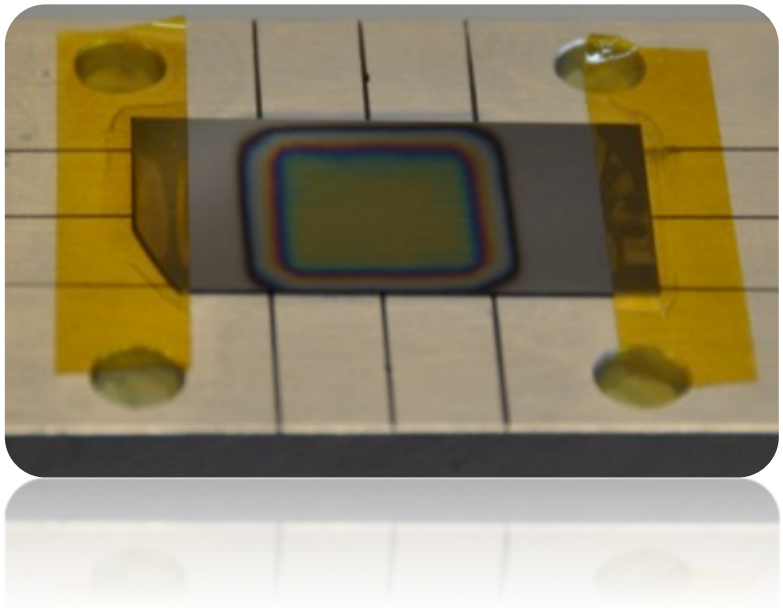
- Ar/O_2 is typically used for cleaning of polymeric substrates and for removal of unwanted organic layers
- Ar/H_2 is tipically used for celaning of oxydised layers from metals



STYLUS PLASMA NOBLE – DEPOSITION APPLICATIONS

It allows the deposition of functional or protective layers by working with the appropriate chemical precursor



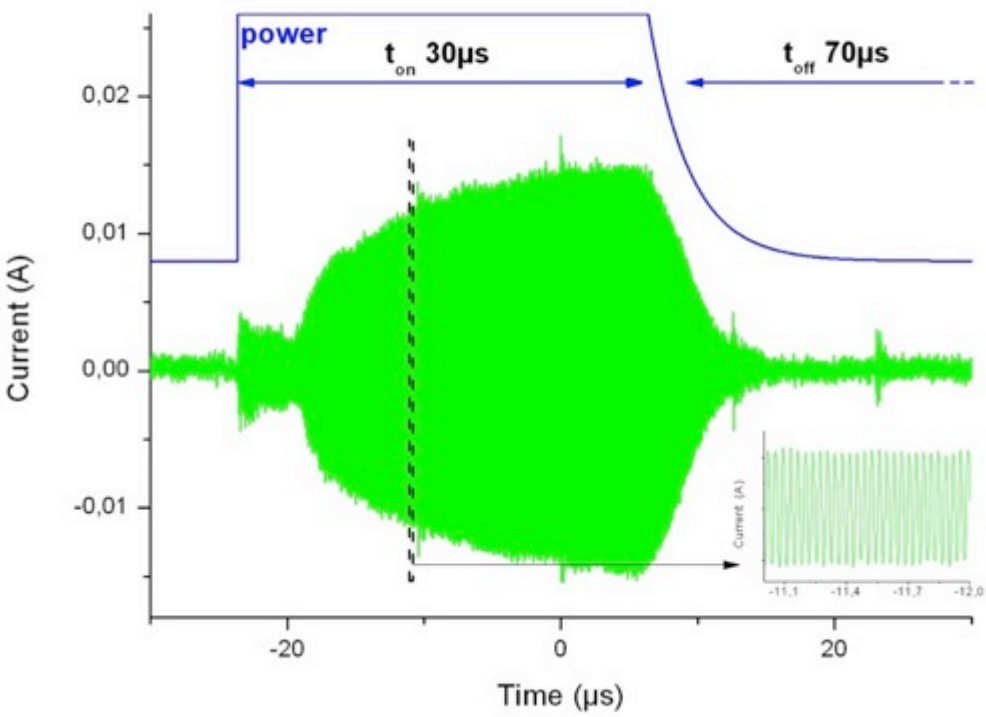


PLASMA STYLUS NOBLE – POWER CONTROL

NADIR
Plasma & Polymers

UNIVERSITÀ DEGLI STUDI DI PADOVA

✓ **Pulsing System**



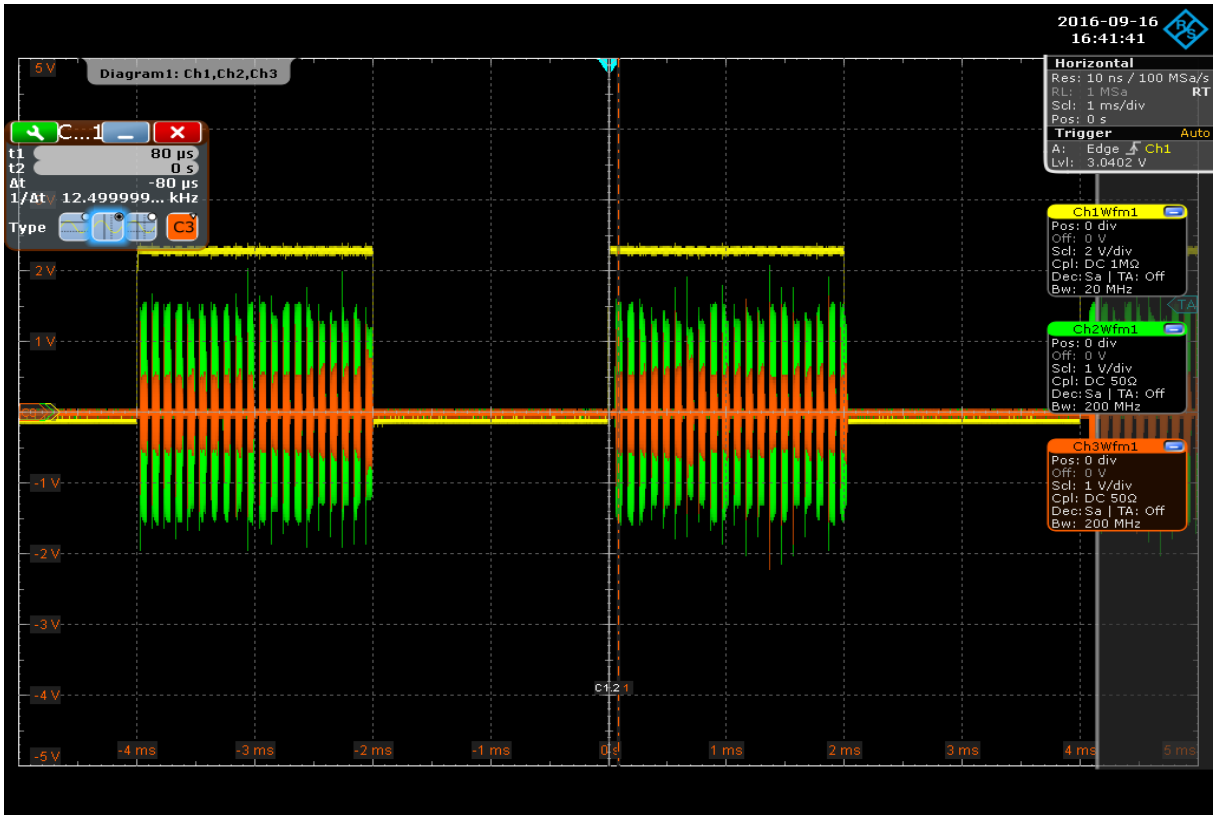
Allows to further reduce temperature treatment and to better control the plasma chemistry of delicate chemical precursor

PLASMA STYLUS NOBLE – POWER CONTROL

NADIR
Plasma & Polymers

✓ **Pulsing System**

Is also possible to work in super pulsed mode by triggering the two power supplies



HV

t_{ON} 2ms
t_{OFF} 2 ms

RF - TRIG

t_{ON} 70 us
t_{OFF} 30 us

PLASMA STYLUS NOBLE – SPECIFICATIONS

Dimensions

Control Unit	3U dimension rack or trolley
Plasma nozzle	cylinder 20 cm long, 250 g
Connection cables	2 m

Supply

Power	10-100W, 220V
Gas 1	Ar 5-10 slm
Gas 2	carrier gas for chemical precursor vapour or reactive gas (0,2-5 slm)
Gas 3	Cooling/Shielding (Air or N_2 10-20 slm)

Treatment

Spot size	1 cm^2
Surface activation rate	1 – 10 s/cm
Deposition rate (cm^2)	0,5 – 10 nm/s cm
Pulsing system	t_{ON} (30 – 10.000 µs)
	t_{OFF} (50 – 10.000 µs)

PLASMA STYLUS NOBLE – APPLICATIONS

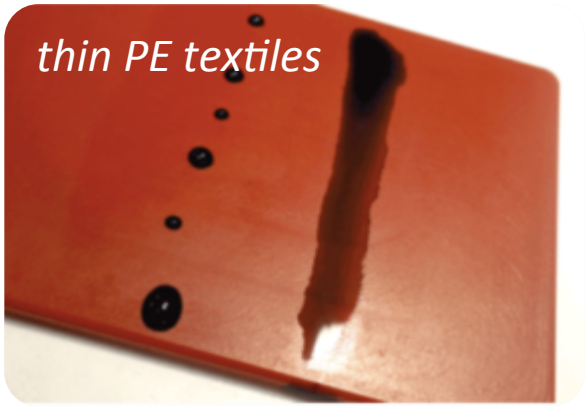
NADIR
Plasma & Polymers

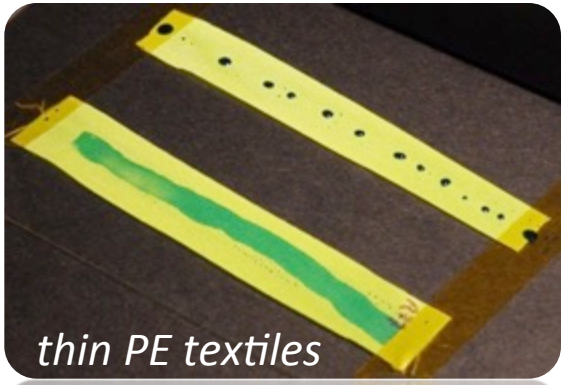
MANUFACTURING & SPORT SYSTEM

PLASMA STYLUS NOBLE – APPLICATIONS

NADIR
Plasma & Polymers

✓ **MANUFACTURING**





Surface activation and cleaning

(before coating application)

Improved wettability and overprint ability

(of varnishes, inks,…)

Adhesion promotion and primer replacement

(gluing processes, rubber injection, VOC free paint, encapsulating resins,…)

Surface protection

(water repellent and anti-corrosion coatings)

PLASMA STYLUS NOBLE – APPLICATIONS

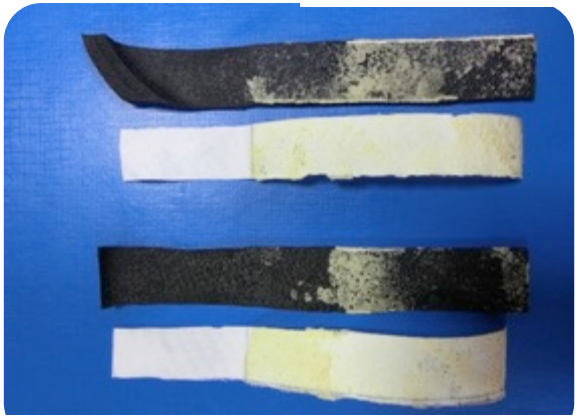
NADIR
Plasma & Polymers

✓ **MANUFACTURING & SPORT SYSTEM**

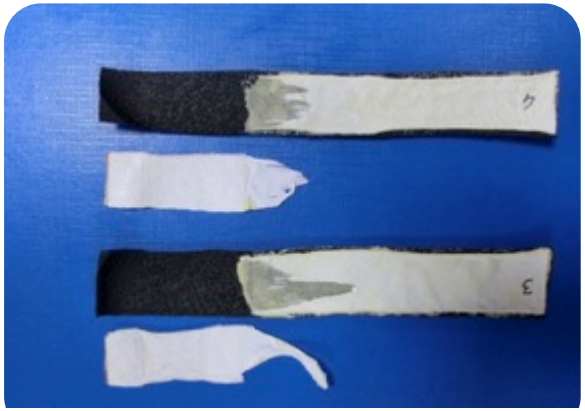
Nadir Stylus Plasma is a powerful tool for adhesion promotion and **for joining dissimilar materials**.

advanced surface modifications are achievable by grafting chemical species and functionalities for adhesion promotion with the desired joint.

Textile membrane on rubber



Adhesive rupture for not treated samples



Cohesive rupture for treated samples

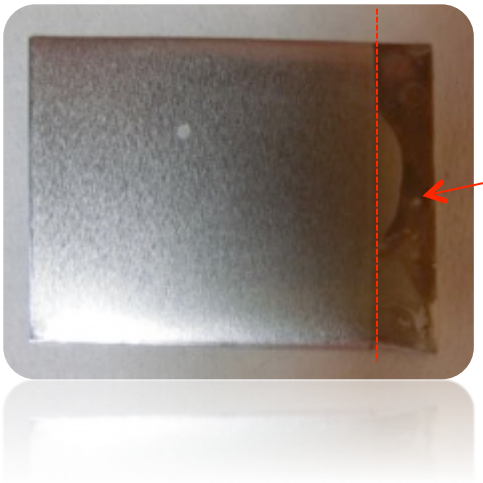
allow the replacement of common solvent-based primers, guaranteeing the desired adhesion performance with environmentally friendly and solvent-free processes.

PLASMA STYLUS NOBLE – APPLICATIONS

NADIR
Plasma & Polymers

✓ **MANUFACTURING & SPORT SYSTEM**

Protective and anticorrosion Coatings



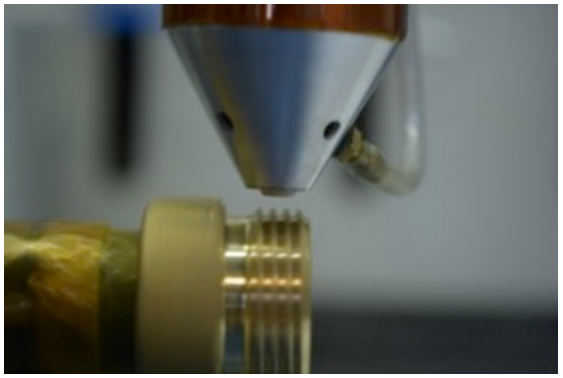
Surface treatment of technical textiles
Sails bonding, flame retardants, …

Improved composite materials properties
(also in collaboration with an italian player of composite materials)

Enhanced adhesion and joining between composite materials and metals
(such as aluminum vs carbon fiber, …)

PLASMA STYLUS NOBLE – APPLICATIONS

Metal Cleaning of metallic valves
for
Threadlocking glue adhesion improvement



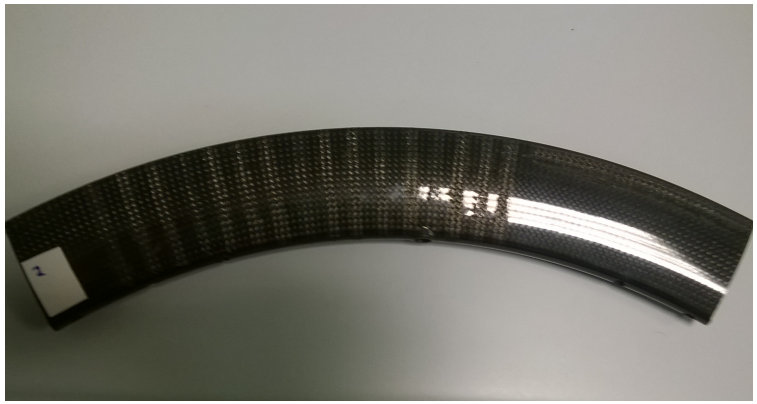
Result:

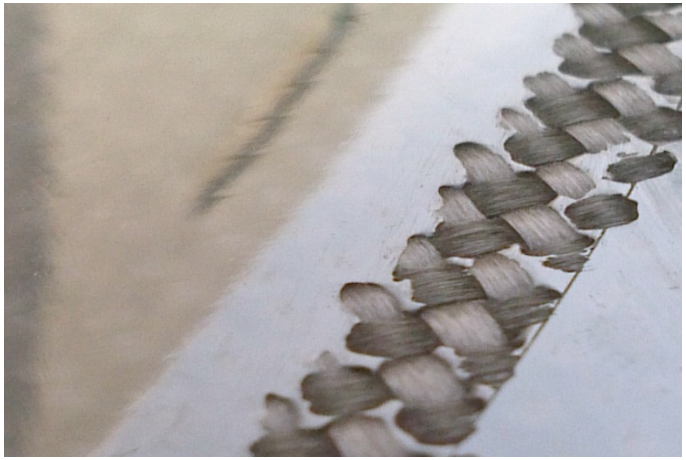
tightening torque
+ 30% improvement

PLASMA STYLUS NOBLE – APPLICATIONS

Localised epoxy resin removal
for
advanced production processes

Carbon fiber exposures without breaking or burning fibers





Result:

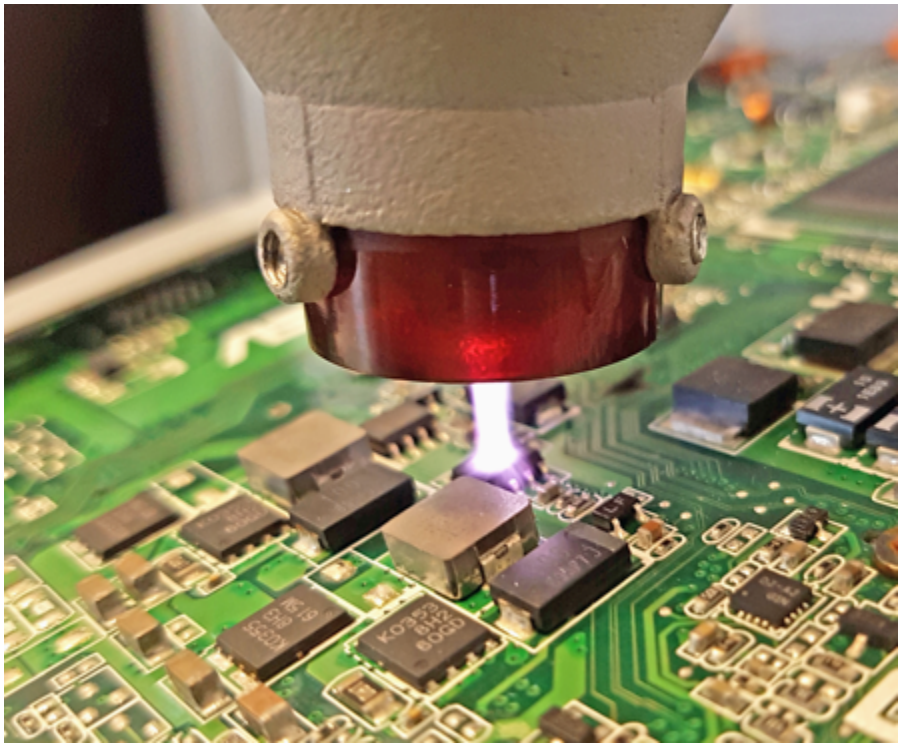
Controlled Epoxy resin removal
1 m/min

PLASMA STYLUS NOBLE – APPLICATIONS

Printed Circuit Boards (PCB)
Surface treatment
for

Cleaning
Etching
Bonding
Adhesion
Polymerisation
Functionalisation

….. Without damaging electrical components



PLASMA STYLUS NOBLE – APPLICATIONS

CULTURAL HERITAGE

PLASMA STYLUS NOBLE – APPLICATIONS

NADIR
Plasma & Polymers

✓ **CULTURAL HERITAGE**

Metal cleaning

(iron, negatives, jewellery, textiles, …)

Biological cleaning on stone, paper

(Lichens, moulds)

Organic layers removal on paintings, stone, paper

(graffiti, aged varnishes, dirt, ink, …)

Modern art

(Plastic and foams restoration, …)

PLASMA STYLUS NOBLE – APPLICATIONS

NADIR
Plasma & Polymers

✓ **CULTURAL HERITAGE**

Università Ca'Foscari Venezia

SMP PHOTO CONSERVATION
Fine Art & Historic Photographs

Plasma Stylus Noble demonstrated to successfully clean and reduce silver oxide and silver sulfide parts avoiding any damage of the delicate nanoparticles structure that compose the daguerreotype image

PLASMA STYLUS NOBLE – APPLICATIONS

NADIR
Plasma & Polymers

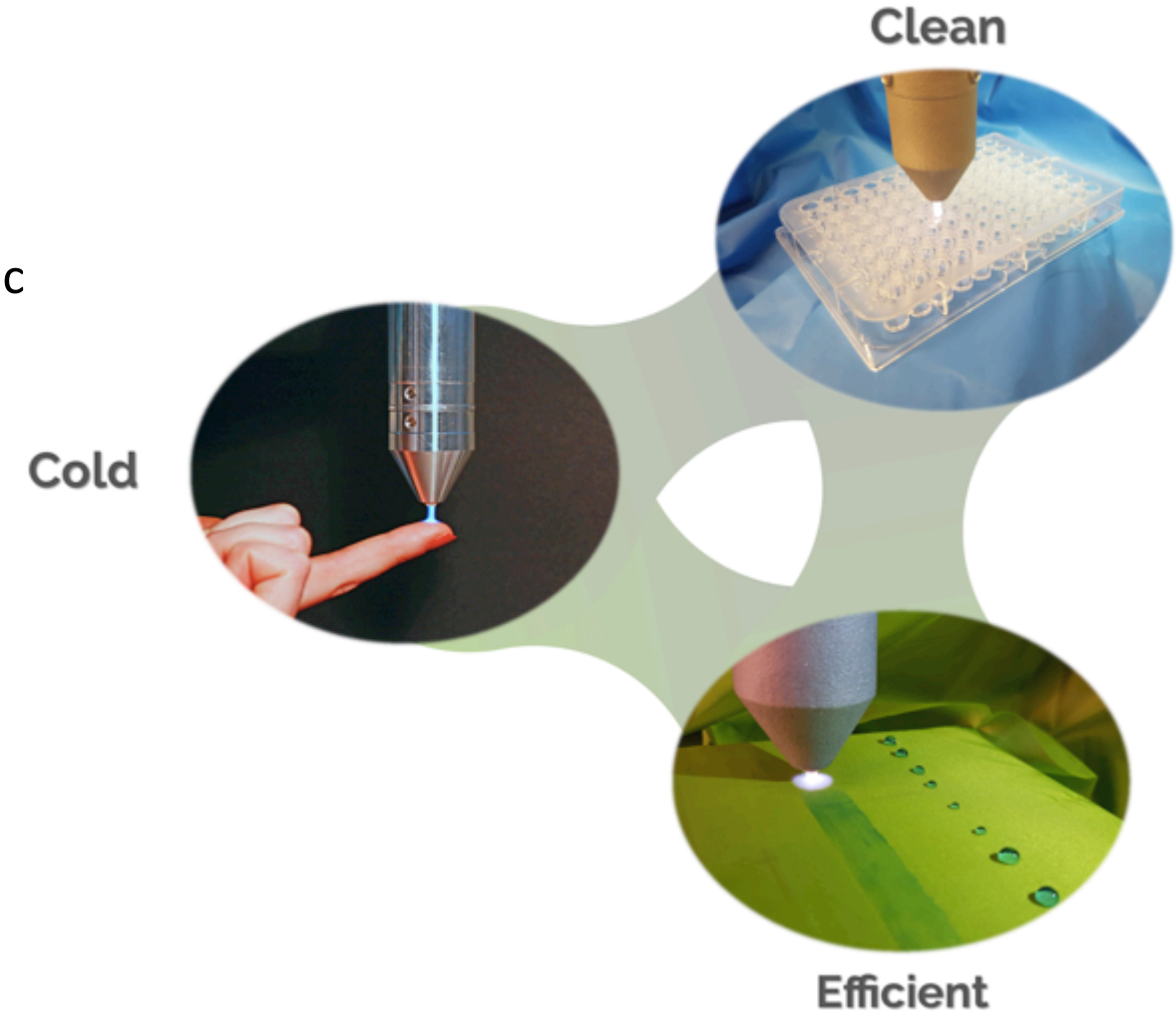
BIOMEDICAL

PLASMA STYLUS NOBLE – APPLICATIONS

NADIR
Plasma & Polymers

- ✓ **BIOMEDICAL**

- ✓ Hydrophilic / hydrophobic
- ✓ Rough Controlled
- ✓ Textured
- ✓ Antifouling
- ✓ Haemocompatible
- ✓ Anti-thrombogenic
- ✓ Protective
- ✓ Sterile
- ✓ others

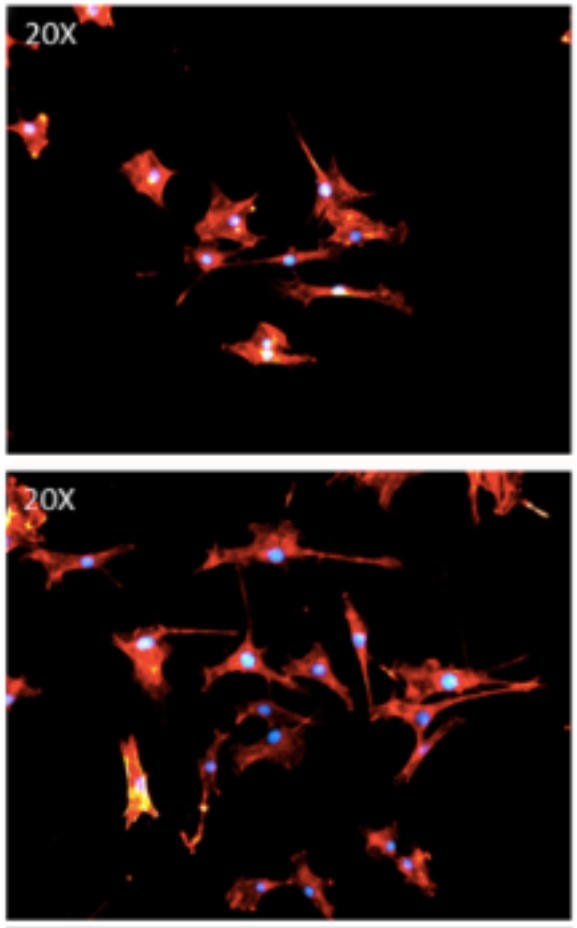


PLASMA STYLUS NOBLE – APPLICATIONS

NADIR Plasma & Polymers

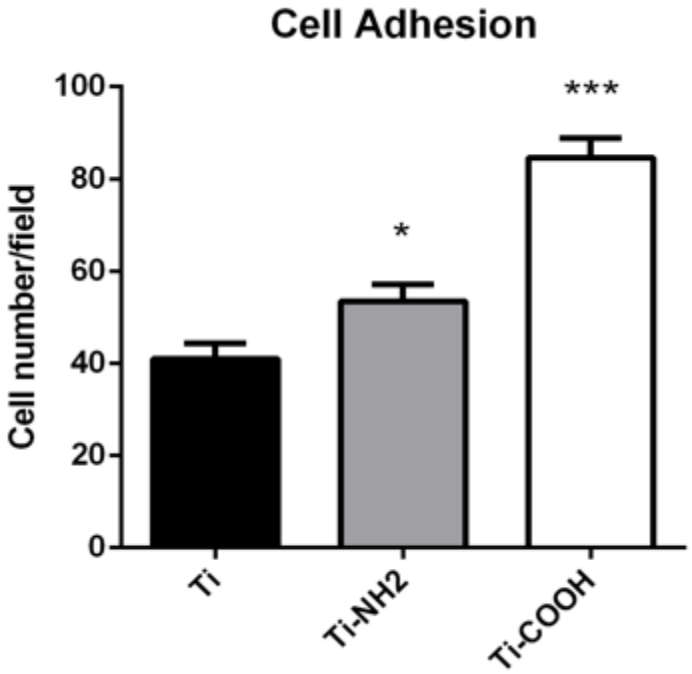
✓ **BIOMEDICAL**

UNIVERSITÀ DEGLI STUDI DI PADOVA | UNIVERSITA DEGLI STUDI DI TORINO



Sterilisation and Implants functionalization for cell adhesion improvement

Ti samples show higher quantity of absorbed proteins and improved osteoblast cells adhesion



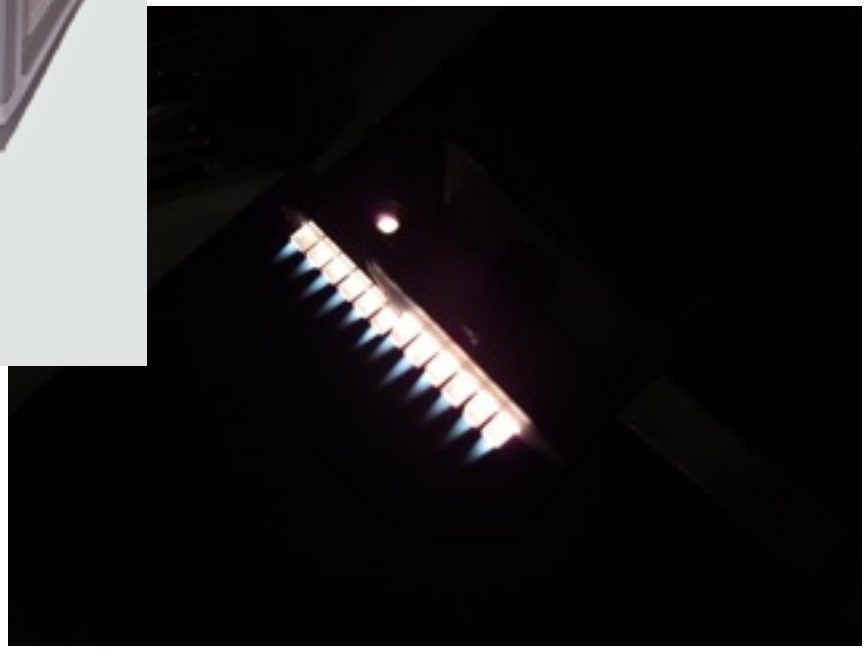
Mussano et al. *Applied Surface Science 409 (2017) 314–324*

PLASMA STYLUS NOBLE – APPLICATIONS

Video Available at the following link:

http://www.nadir-tech.it/it/tecnologie/

CUSTOMISED PRODUCTS

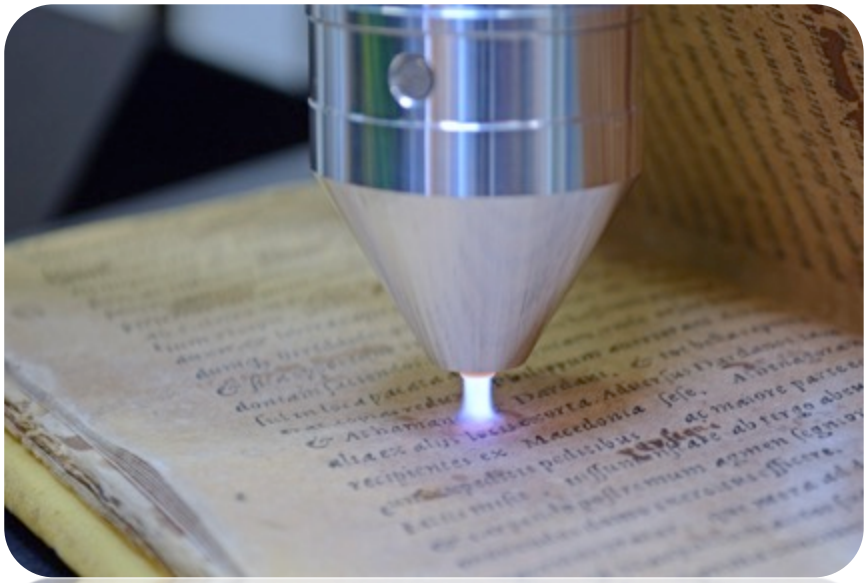


6 jets modular Cold Plasma Device

STYLUS PLASMA NOBLE

NADIR
Plasma & Polymers

High efficiency at Low temperature!



CONTACTS

NADIR S.R.L.

C/O UNIVERSITY OF VENICE
VIA TORINO 155/B
30172, MESTRE (VE)
ITALY

PH. +39 041 2346711
EMAIL
SCOPECE@NADIR-TECH.IT
INFO@NADIR-TECH.IT