Les Plasmas – 4ième. état de matière

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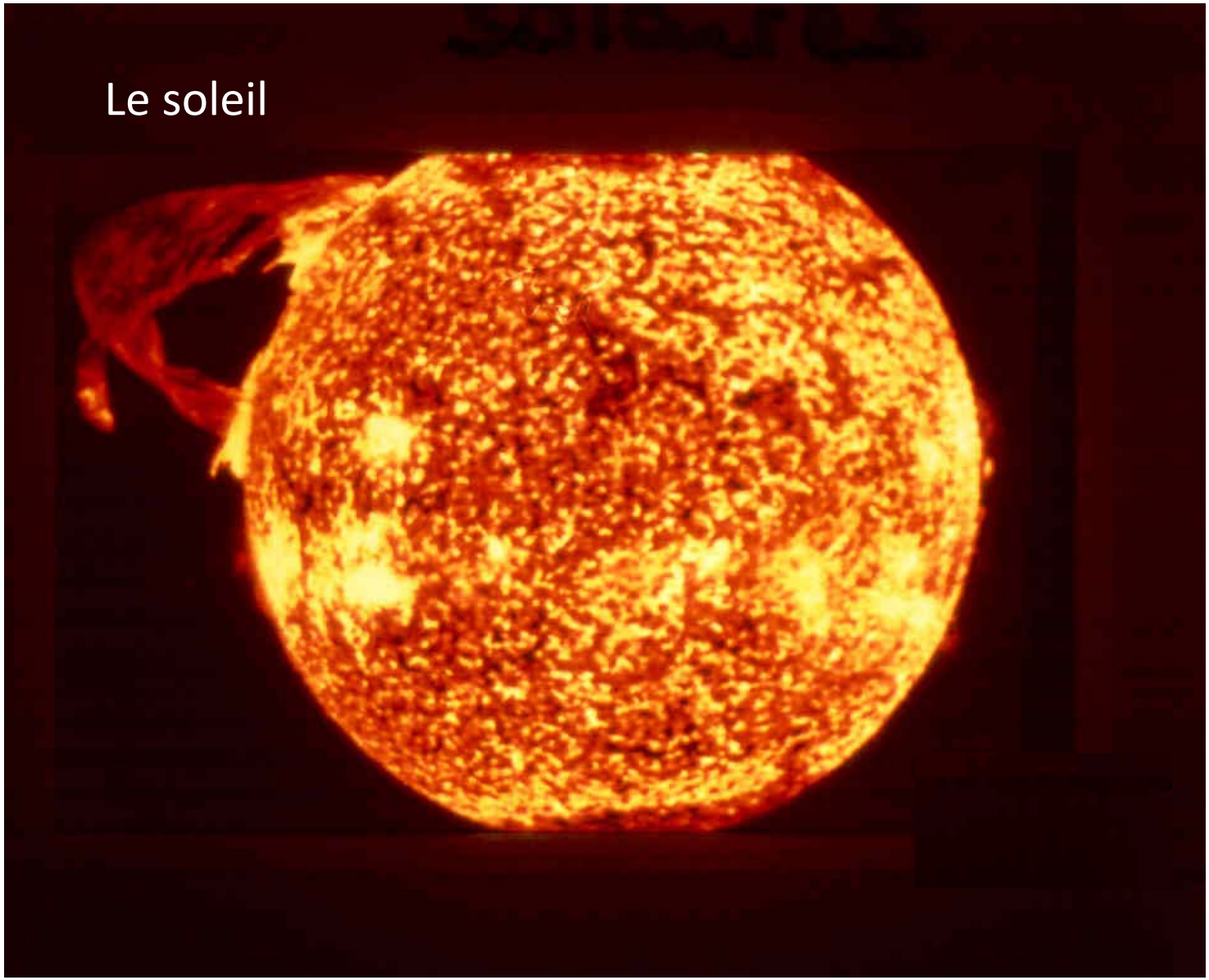
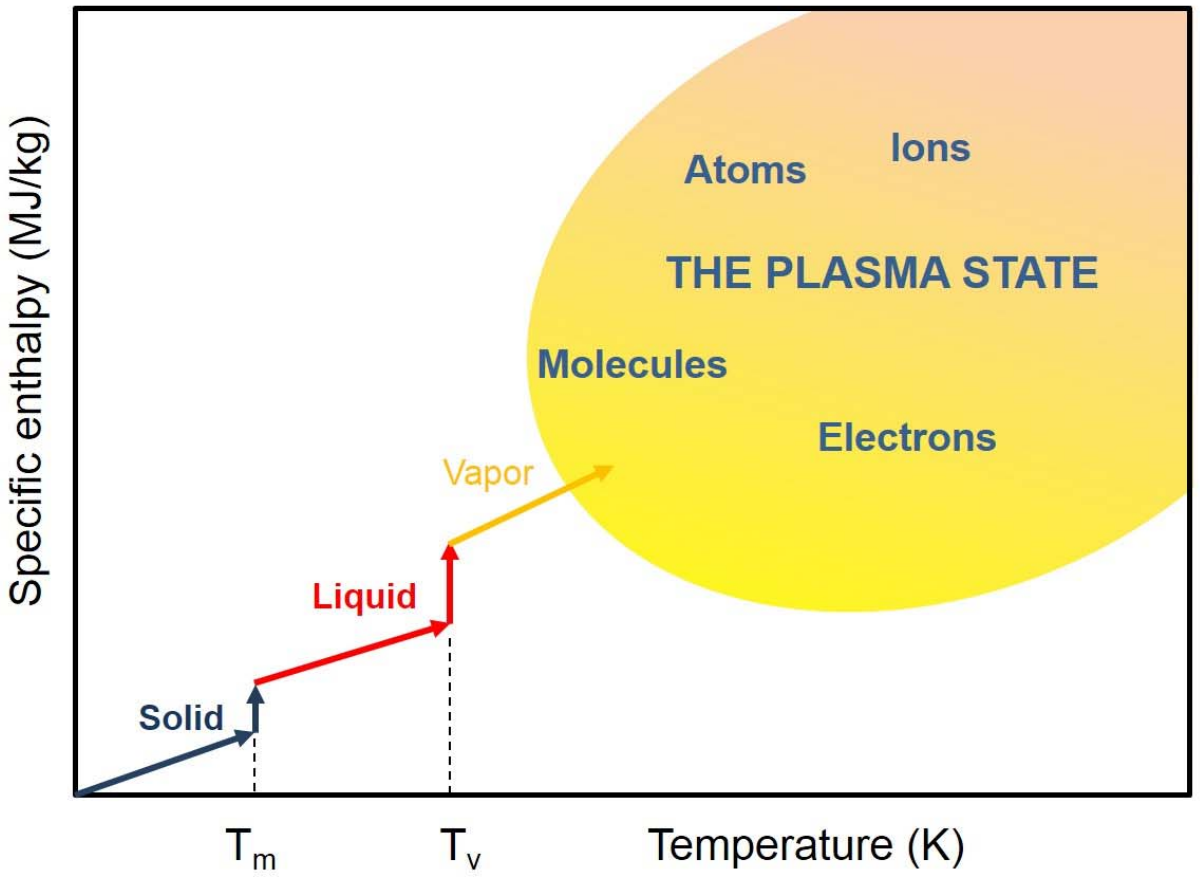
Le soleil



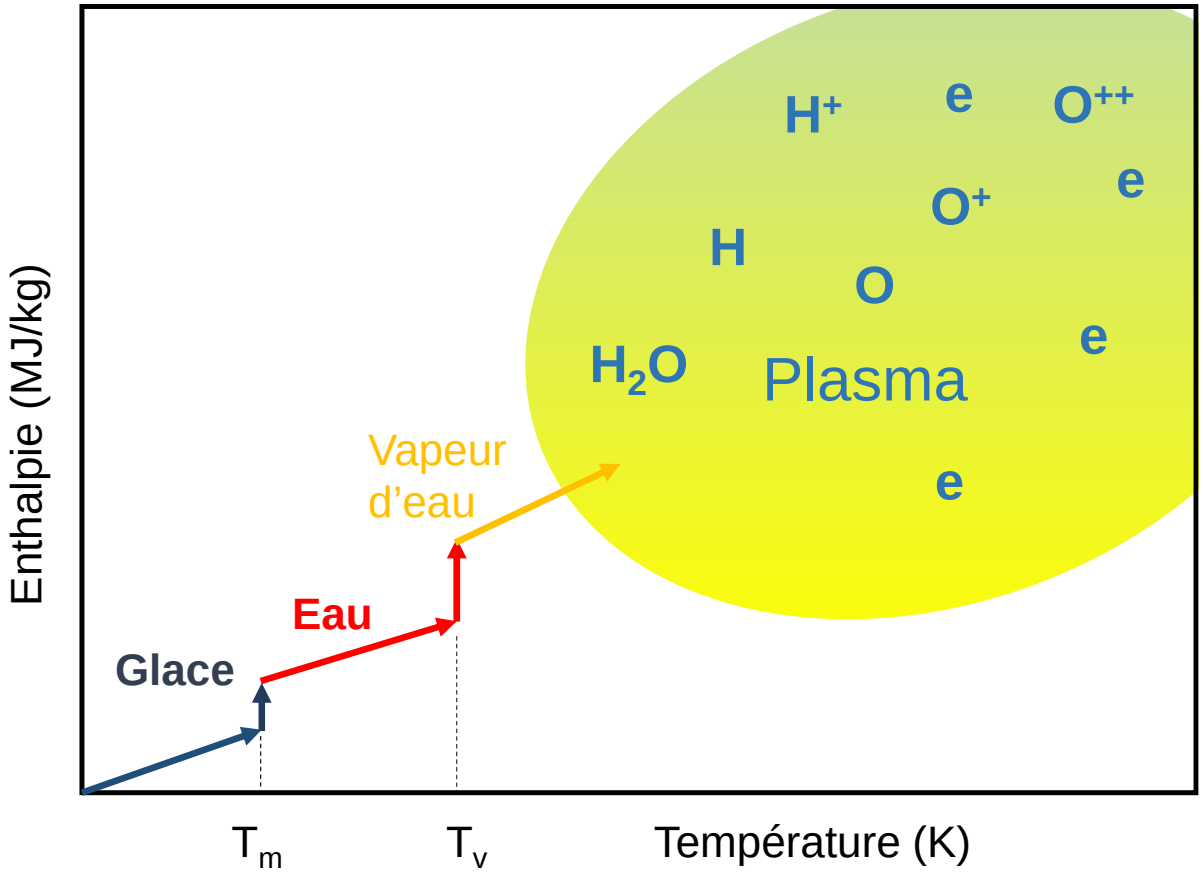
Ionosphère /Aurora

Éclairs

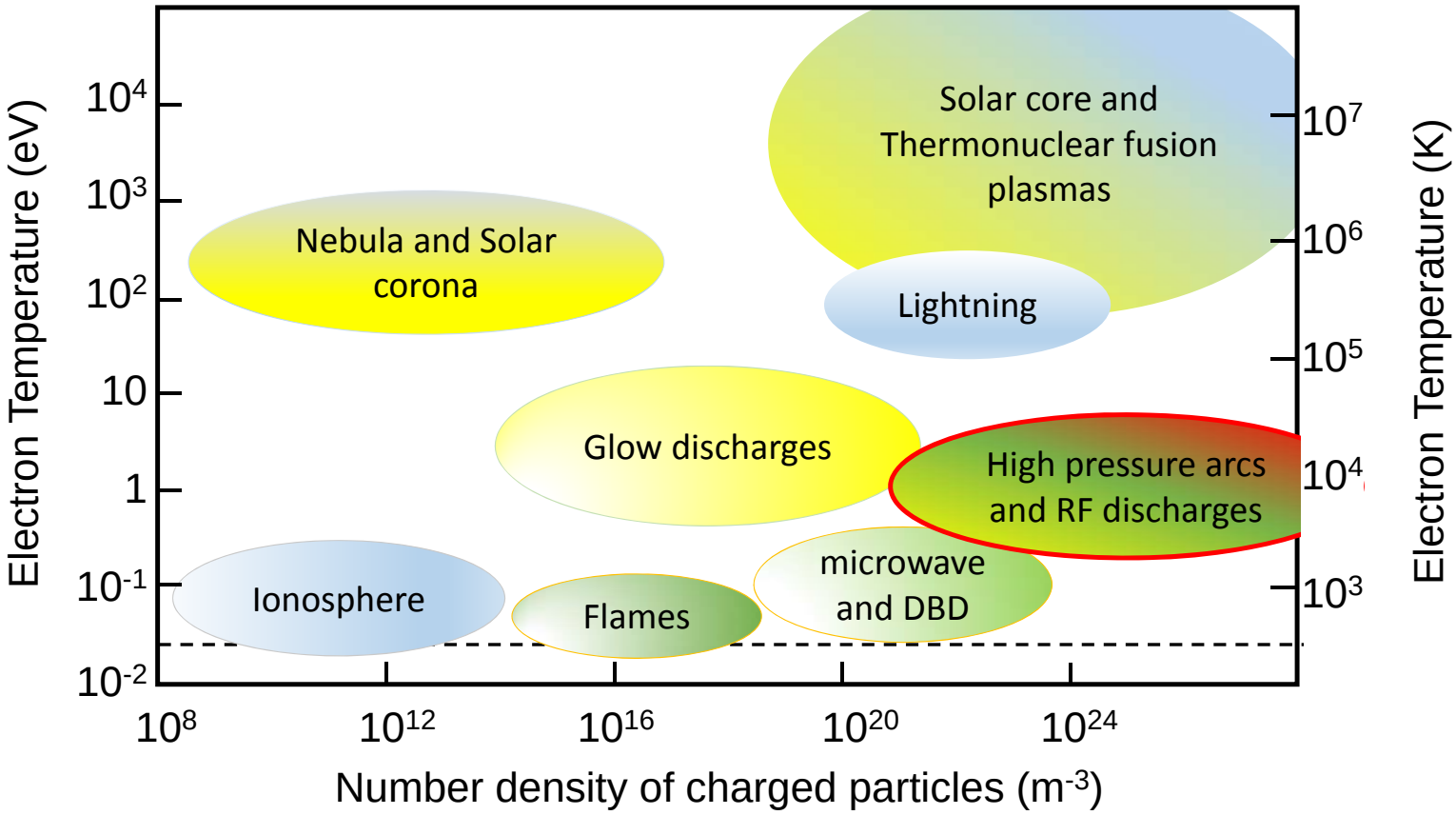
Les Plasmas 4ième état de matière



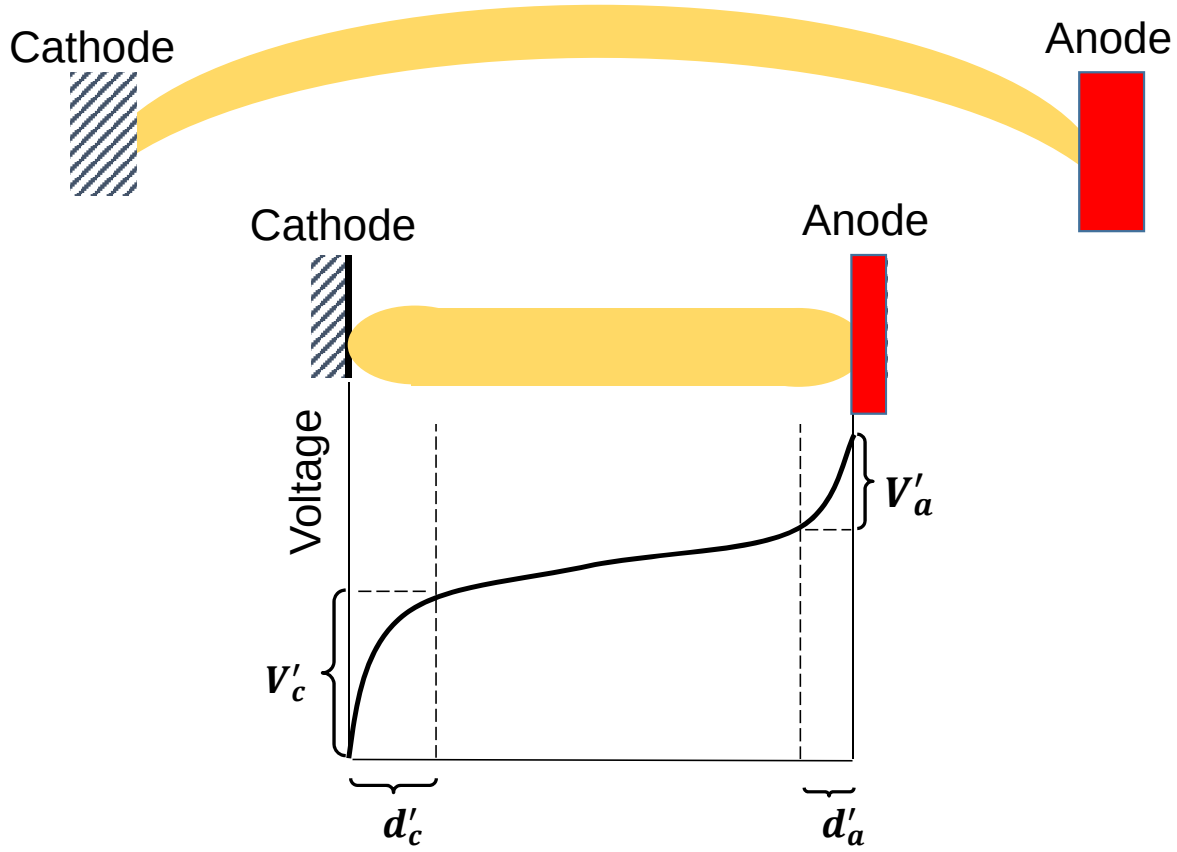
Les Plasmas 4ième état de matière



Les Plasmas 4ième état de matière

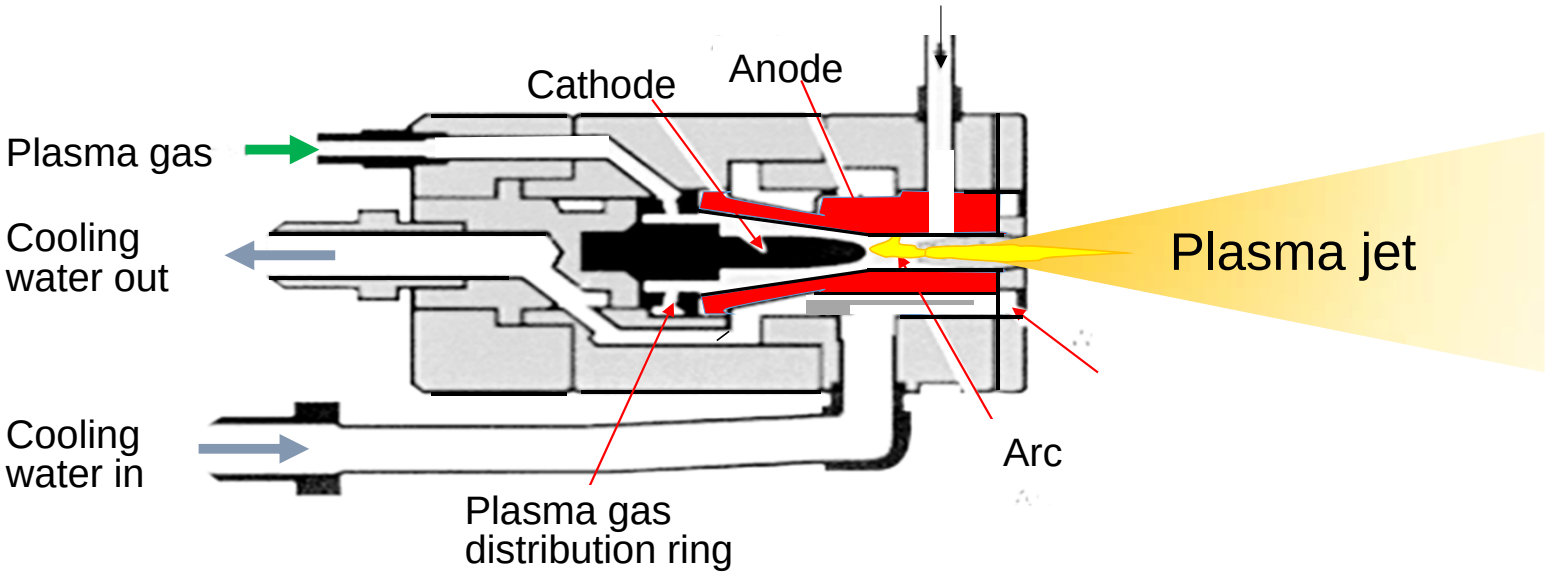


Génération des plasmas L’arc électrique



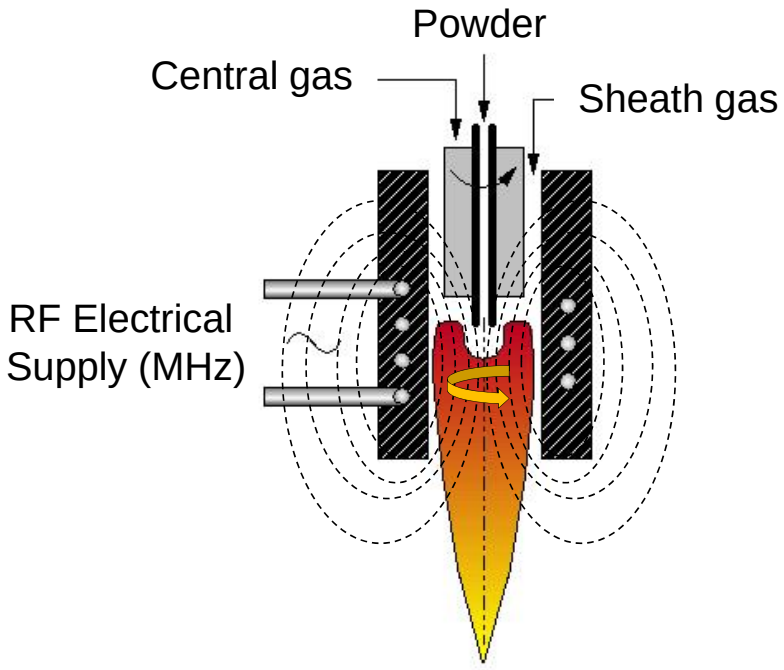
Génération des plasmas

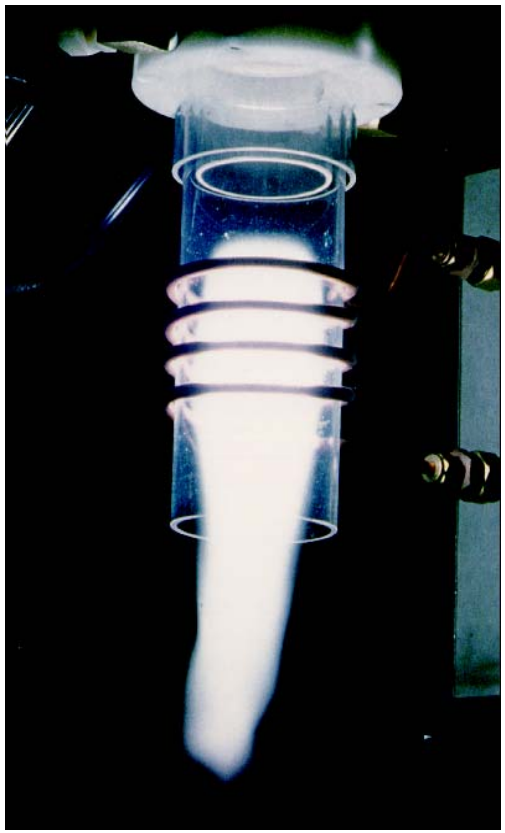
Torche à plasma à courant continu



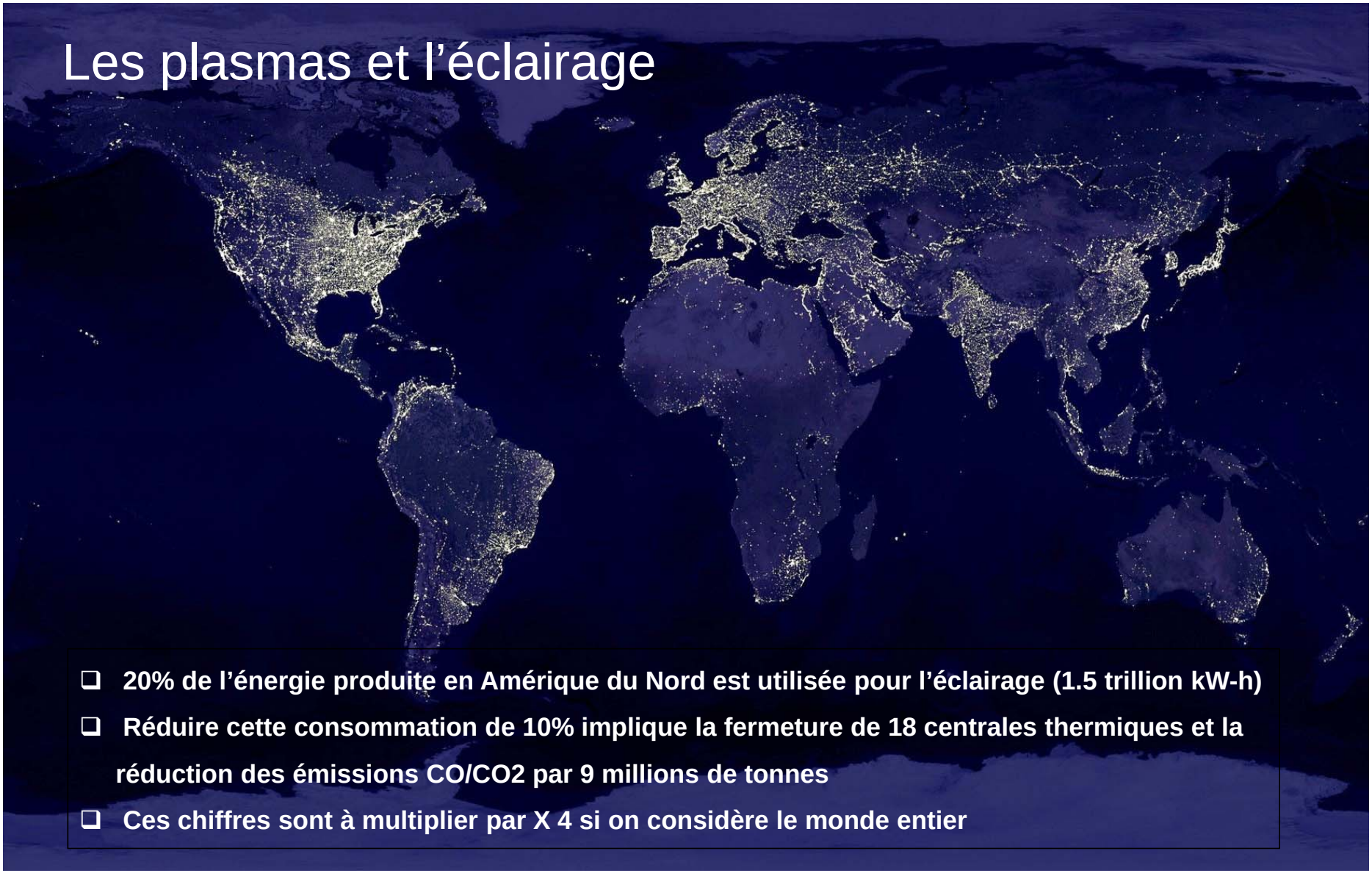
Génération des plasmas

Torche à plasma à induction





Les plasmas et l'éclairage

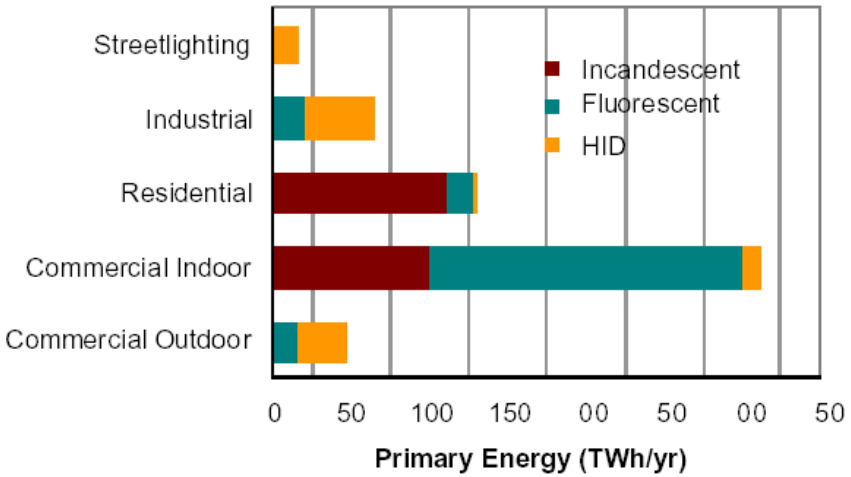


- **20% de l'énergie produite en Amérique du Nord est utilisée pour l'éclairage (1.5 trillion kW-h)**
- **Réduire cette consommation de 10% implique la fermeture de 18 centrales thermiques et la réduction des émissions CO/CO2 par 9 millions de tonnes**
- **Ces chiffres sont à multiplier par X 4 si on considère le monde entier**

Différentes sources de lumière

Source	Efficacité (LPW)	Durée de vie (h)	Ballast
Incandescente	15-25	50-2500	non
Halogène	18-33	25-4000	non
Fluorescente	40-90	10 000	oui
Mercure	20-58	20 000	oui
Mercure UHP	40-70	1000-6000	oui
Sodium HP	65-140	24 000	oui
Xénon Arc court	20-40	400-2000	oui
LED	60-300	> 25 000	non

Light-Emitting Diode (LED)



Les plasmas dans le domaine d’aérospaciale

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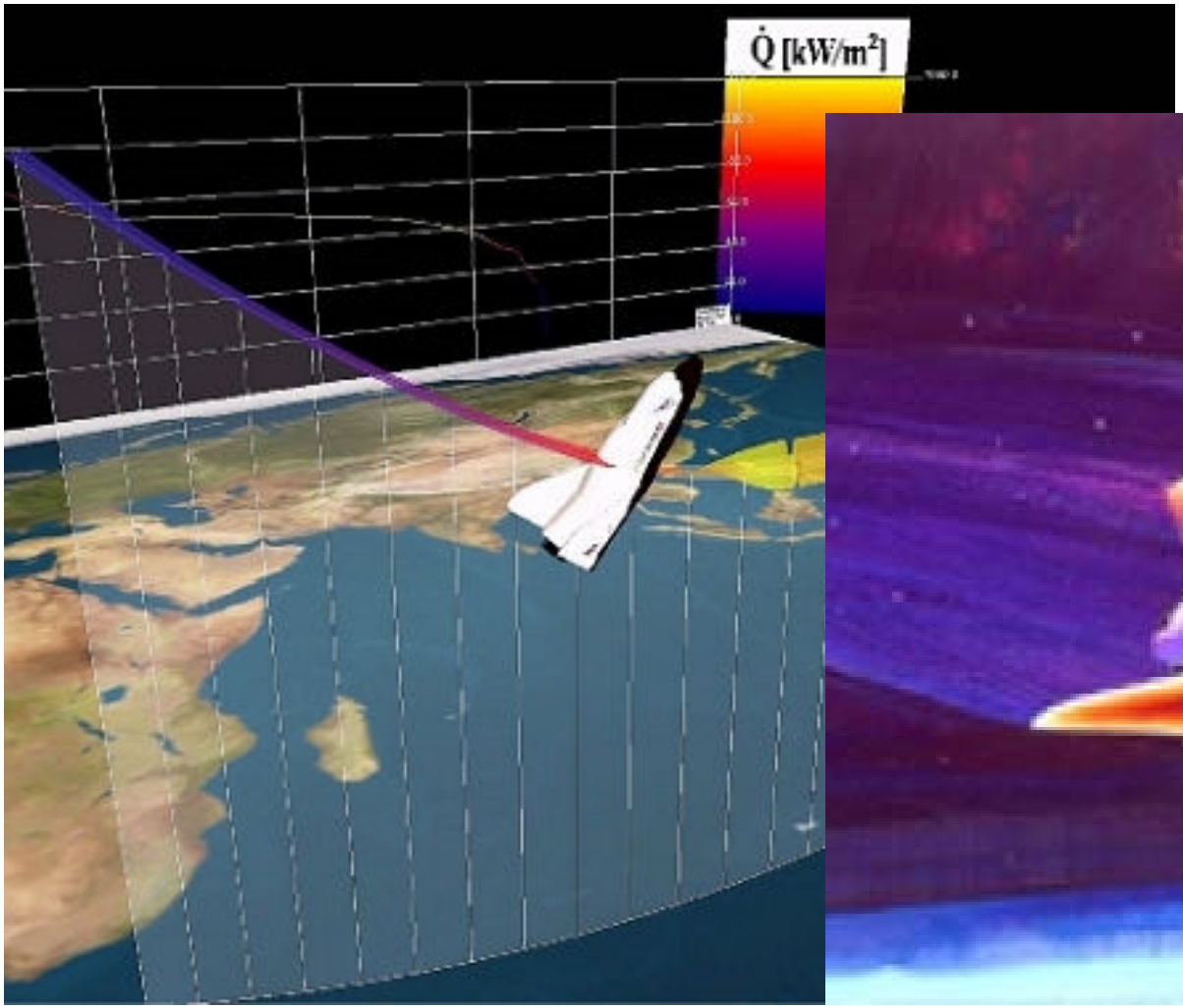
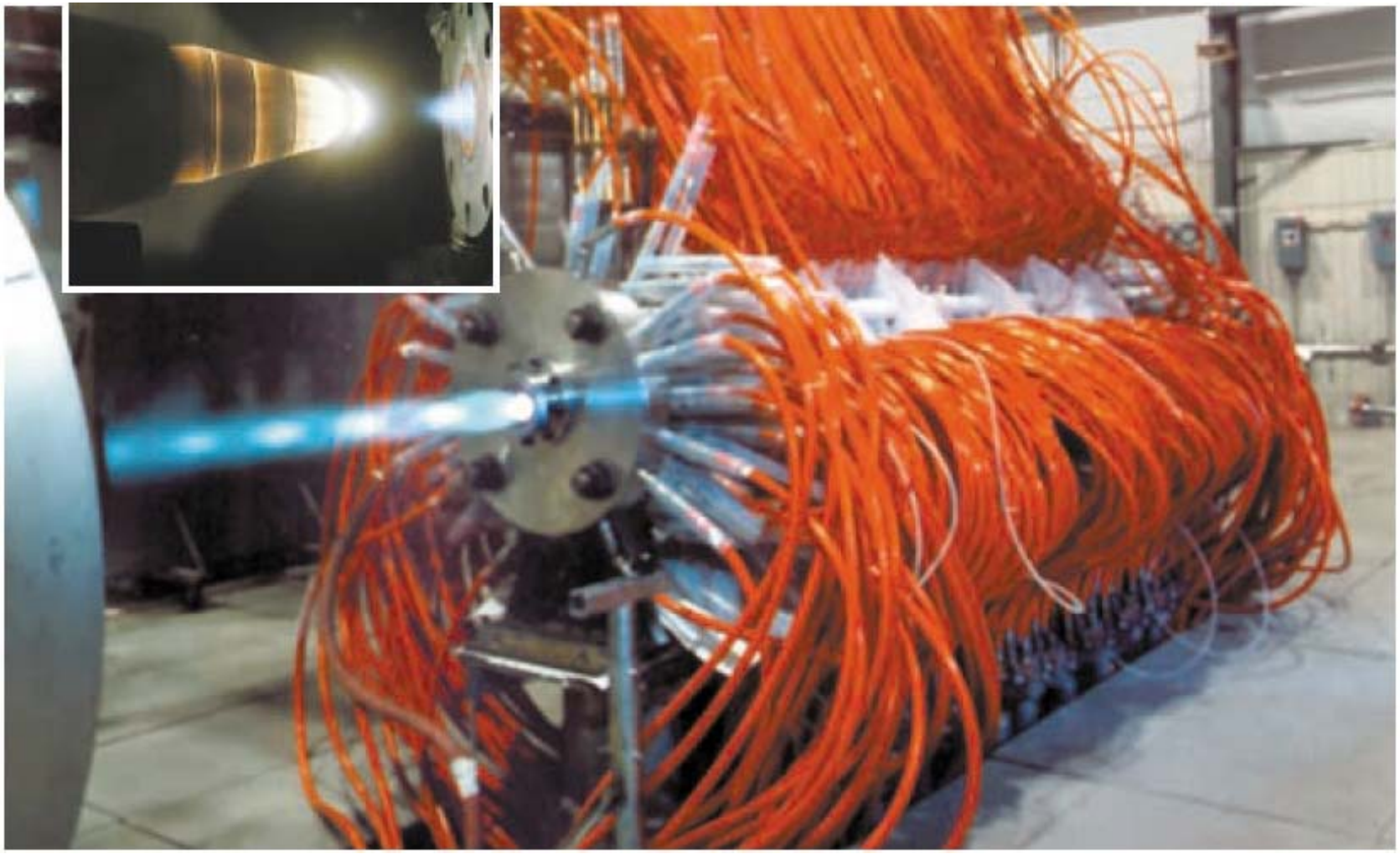
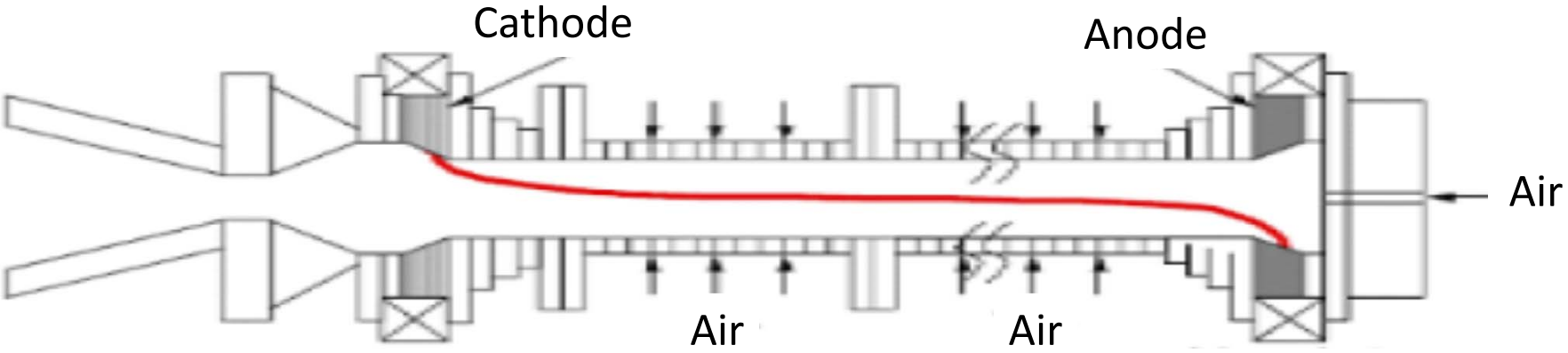


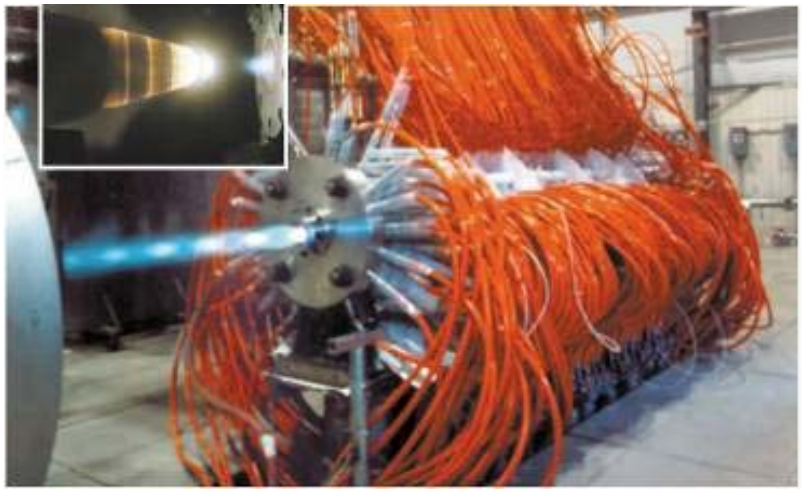
Installations d’essais (30-50 MW) au AEDC – USA



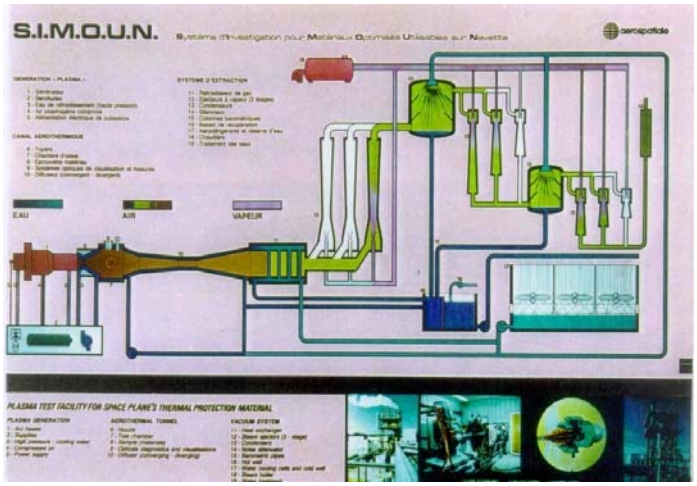
High power dc plasma source Segmented arc torch

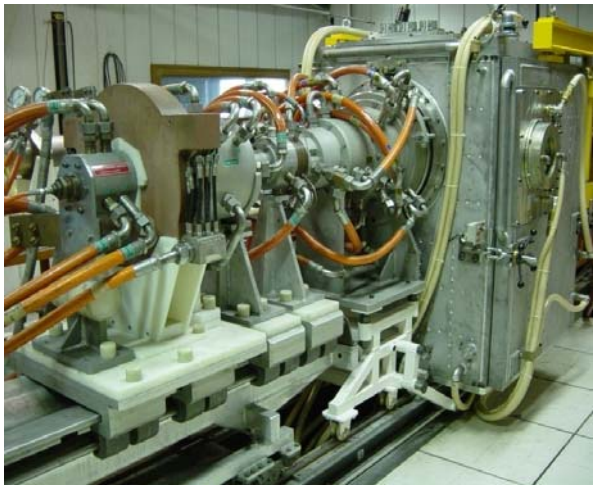


AEDC ARC-HEATED TEST FACILITIES			
Facility Name	***H1***	***H2***	***H3***
Facility Type	**Arc Heater** *(Atm. Exhaust)*	**Arc-Heater** *(Subatm. Exhaust)*	**Arc Heater** *(Atm. Exhaust)*
Max. Run Time *(min.)*	**1 - 2**	**3 - 30**	**1 - 2**
Nozzle Mach No.	**1.8 to 3.5**	**4.0 to 8.3**	**1.8 to 3.5**
Nozzle Exit Diam *(in.)*	**0.75 to 3.0**	**5.0 to 42.0**	**1.2 to 4.5**
Stagnation Pressure *(psia)*	**Up to 1,300**	**Up to 50**	**Up to1,300**
Stagnation Enthalpy *(Btu/lbm)*	**600-8,500**	**1,200-6,000**	**600-8,500**
Mass Flow Rate *(lb/s)*	**0.5-8**	**2-10**	**3-18**
Facility Power *(MW)*	**30**	**50**	**70**



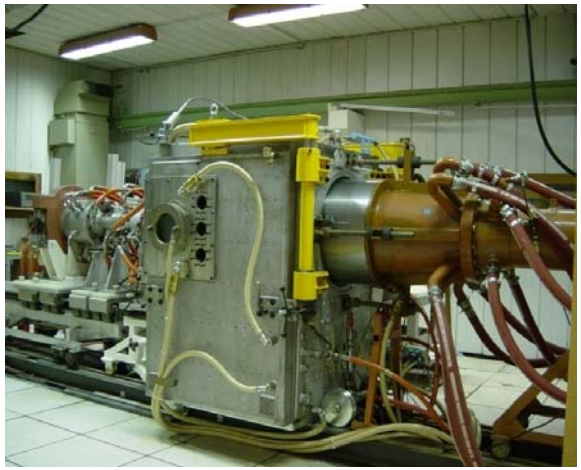
6 MW SIMOUN, France





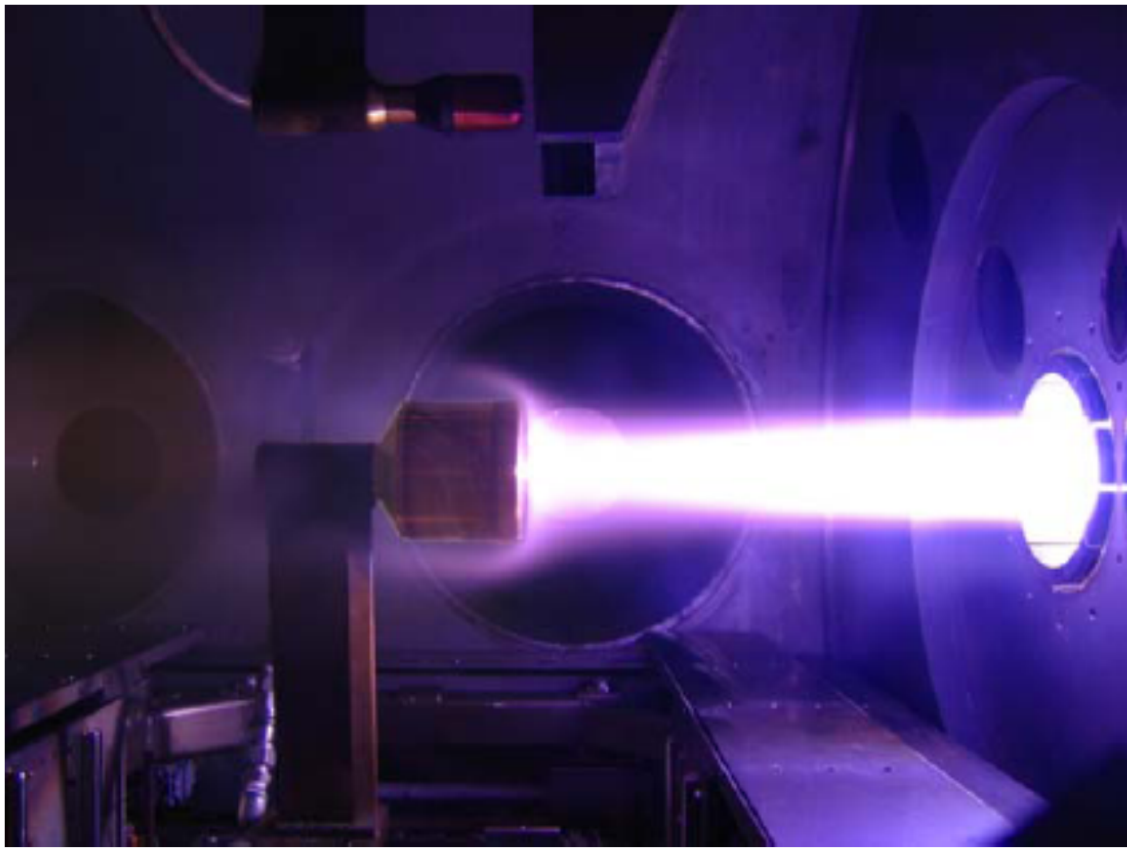
SIMOUN SET UP :

- Generator
- Test chamber
- Vacuum system
- Sample in flow



Scirocco Arc Jet Test Facility, Italy

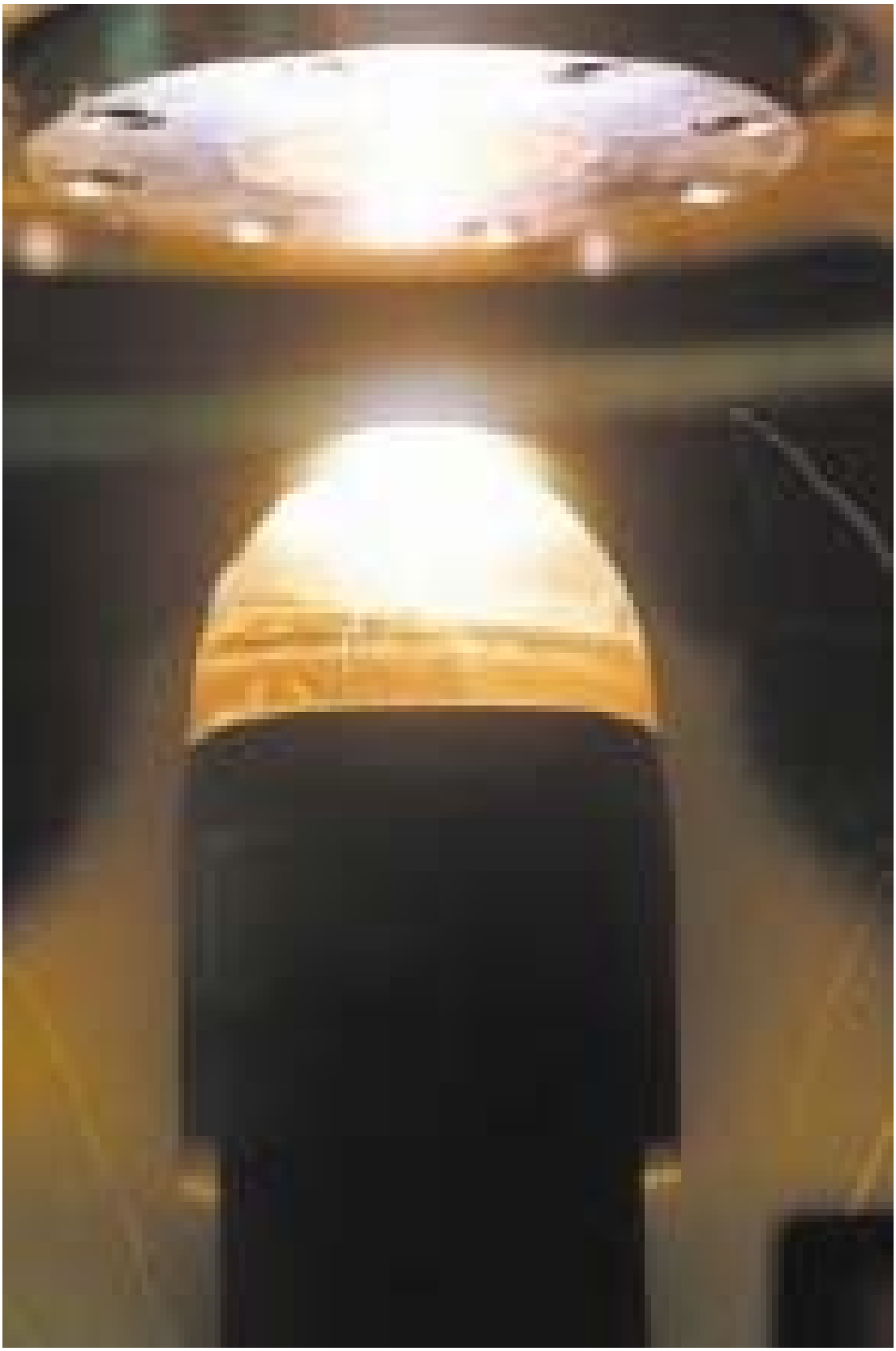
Van Karman Institute, Belgium



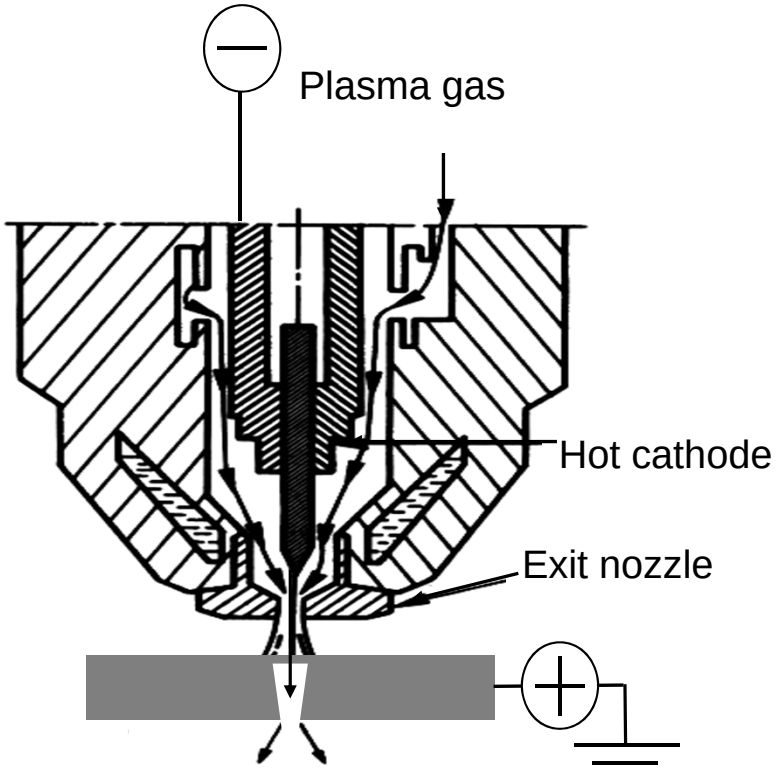
Induction plasma wind tunnel
35 MJ/kg VIK 1.2 MW System

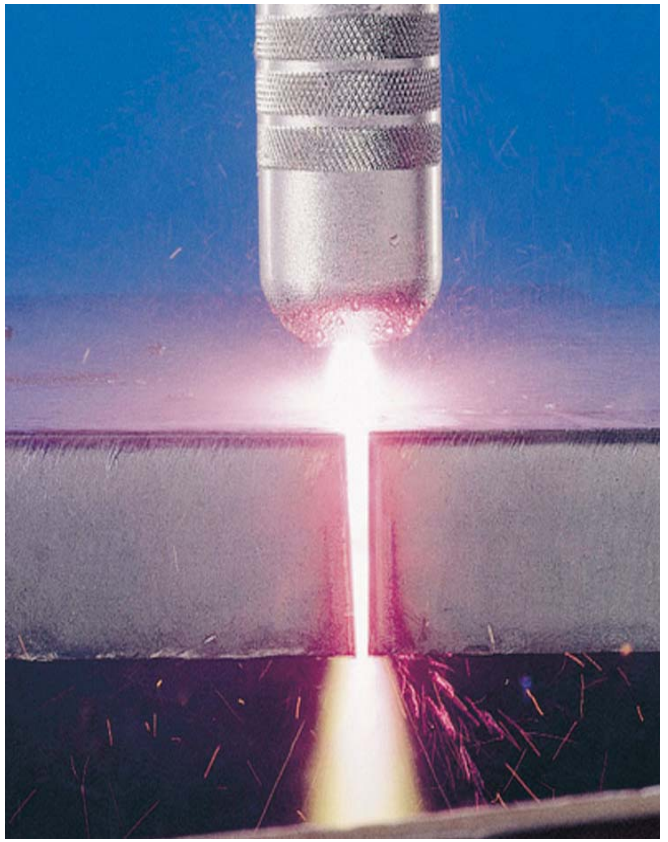
Basic Design parameters

- Altitude (Pressure) : 50-80 km
- Enthalpy : 35 MJ/kg
- Plasma velocity: 9 km/s
- Plasma power level 1 MW
- Gas content Ar, O2, CO2, Air
- Contamination level: None

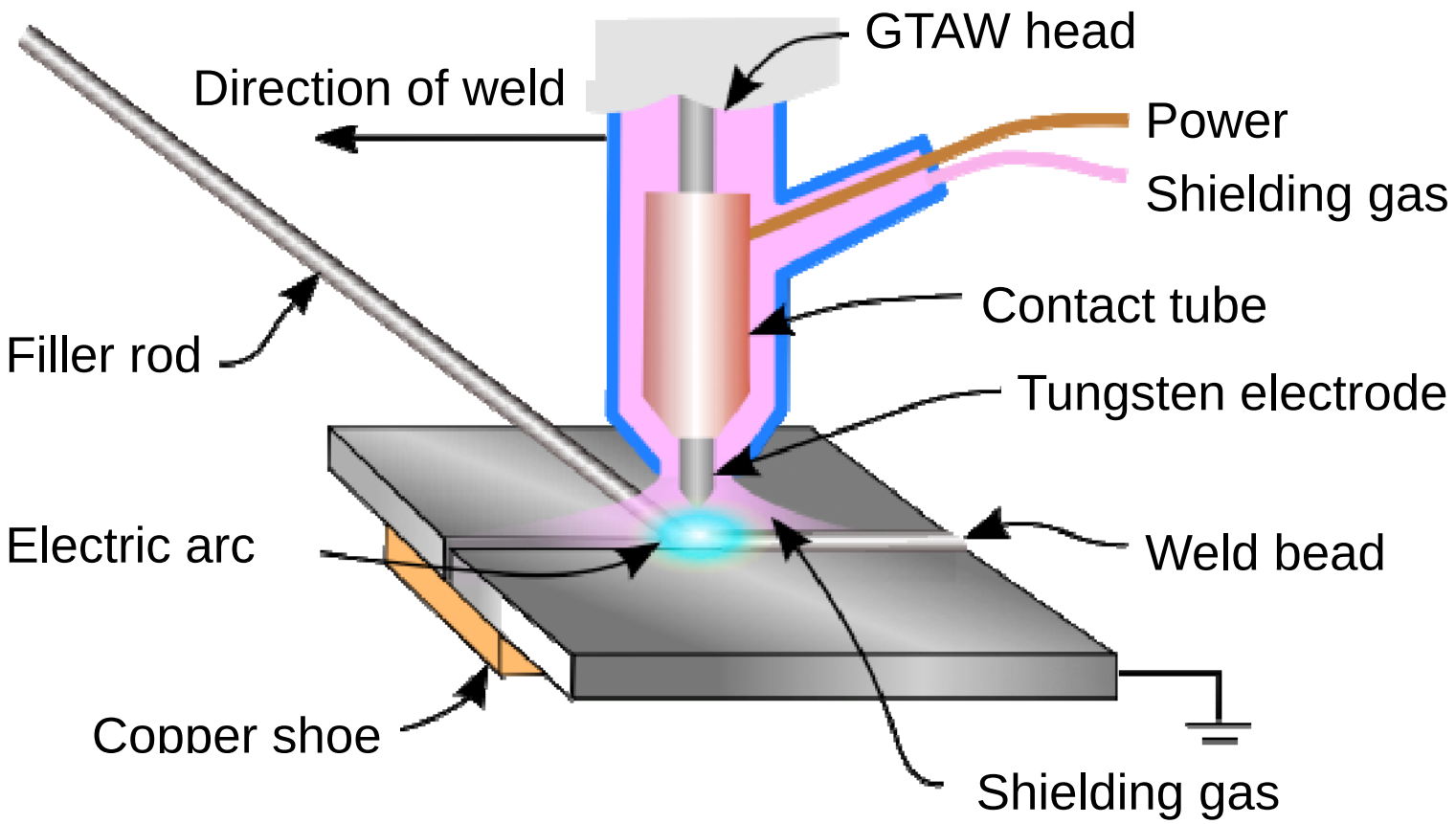


Les plasmas dans le domaine de la coupe

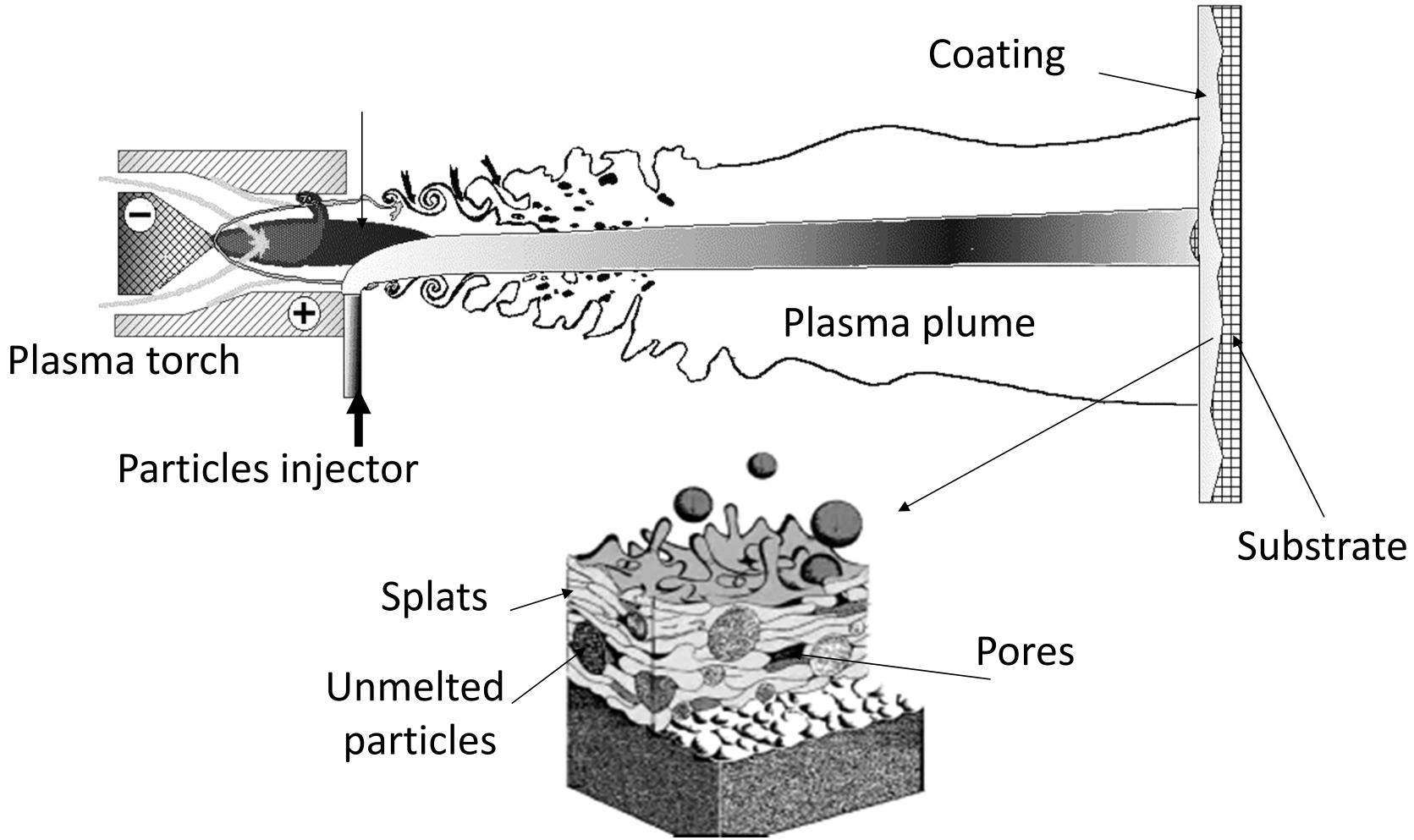




Les plasmas dans le domaine de la soudure



Les plasmas dans le domaine des revêtements

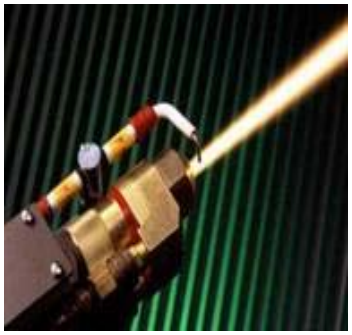


Thermal Spray processes center around powders and wires

Powders

Plasma

HVOF



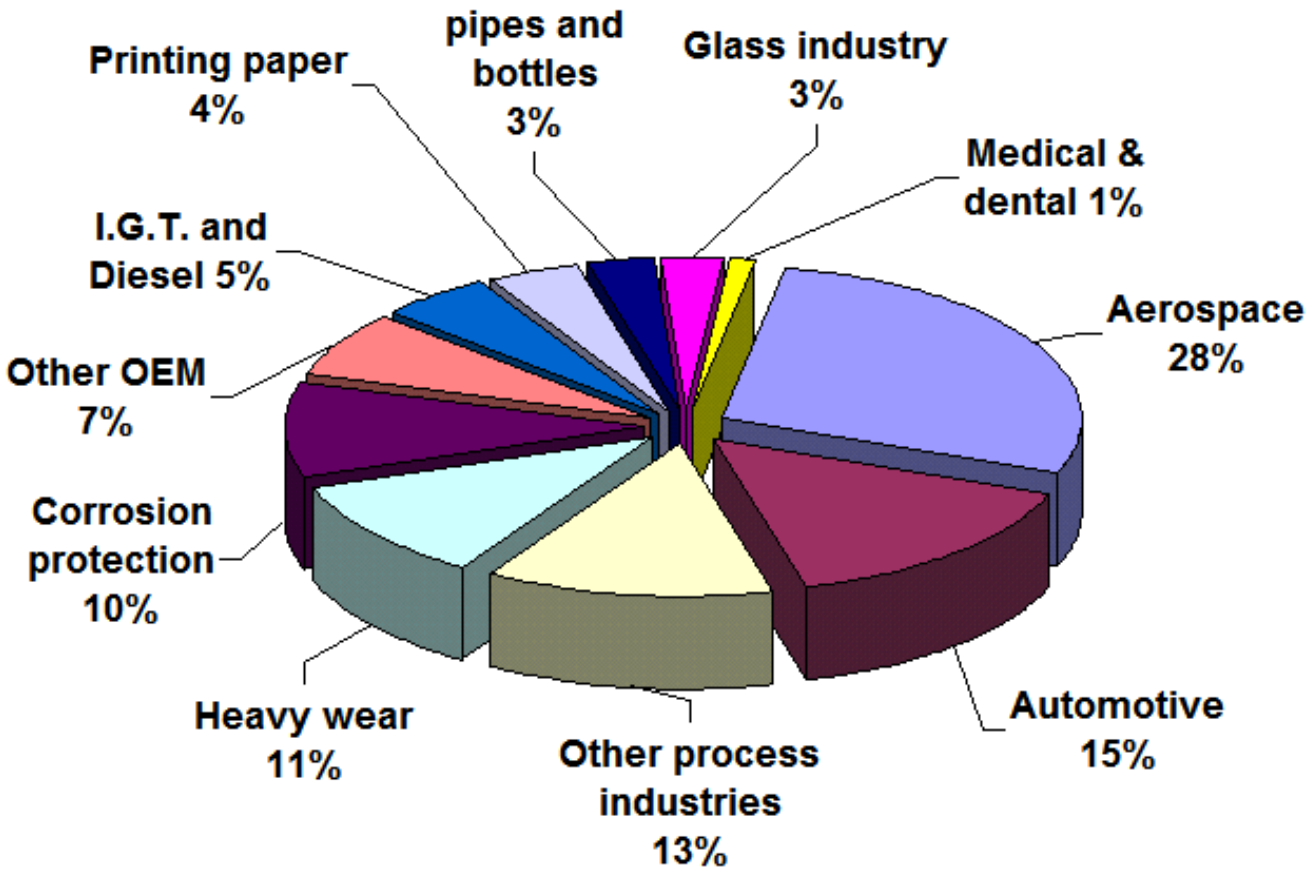
Combustion

Wires

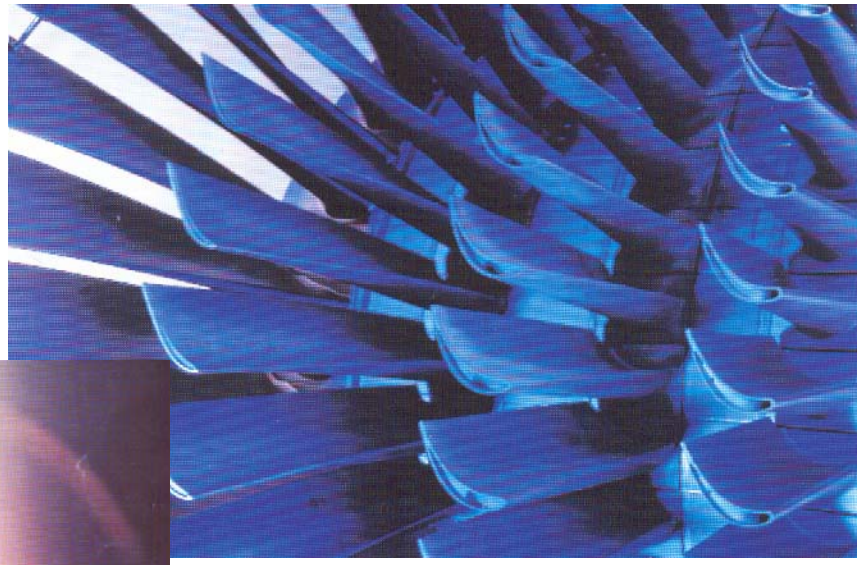
Electric Arc

Combustion

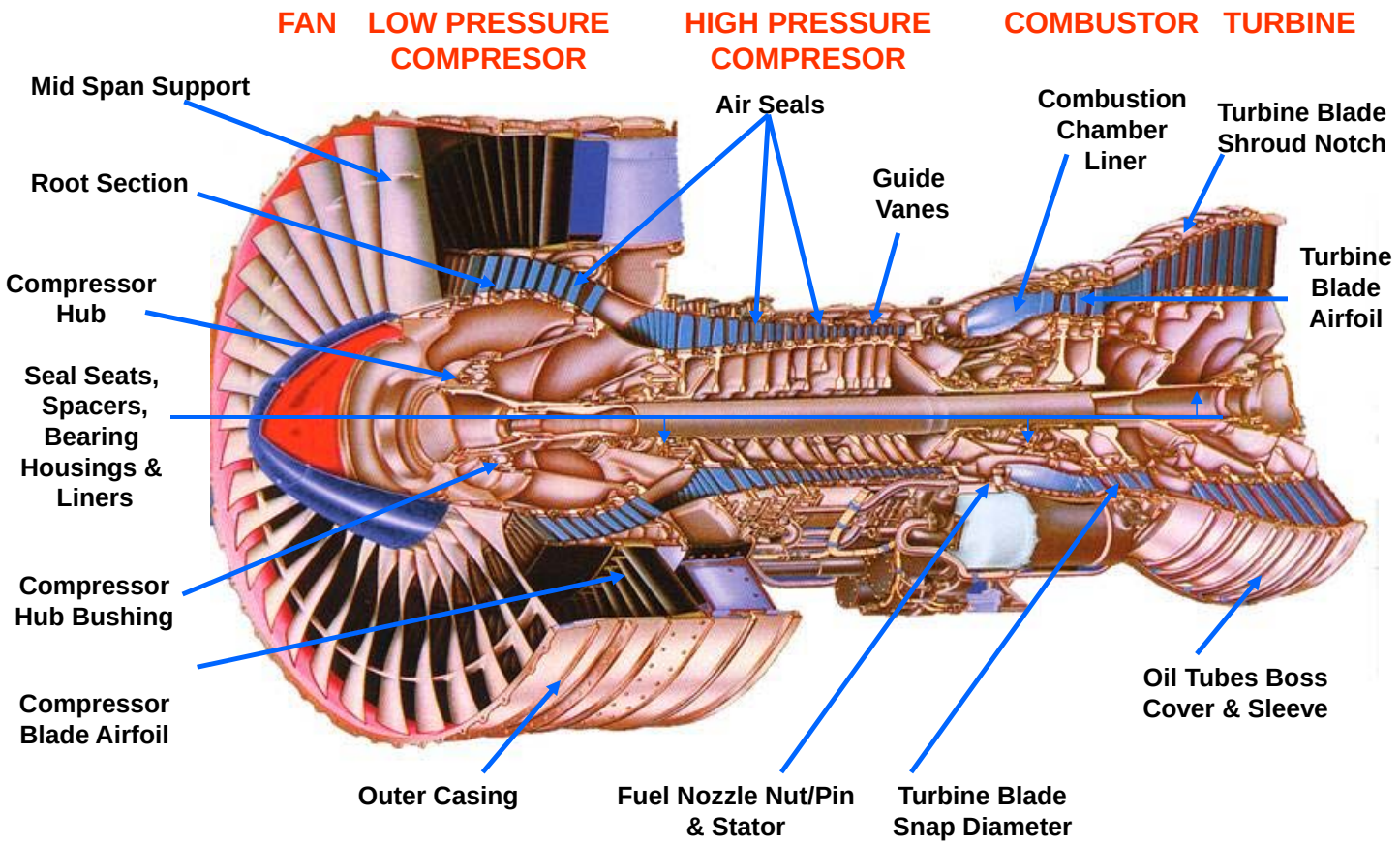
Industrial Applications of Thermal Spray Technology in Europe (After Ducos et al. ITSC-2002)



Plasma sprayed turbine blade coating

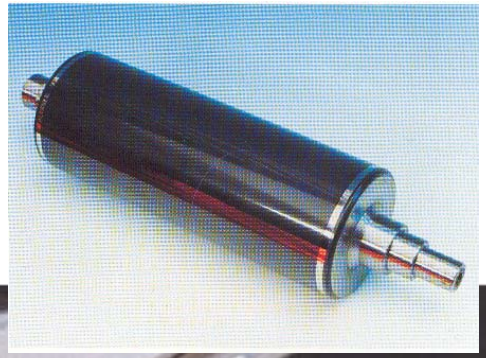


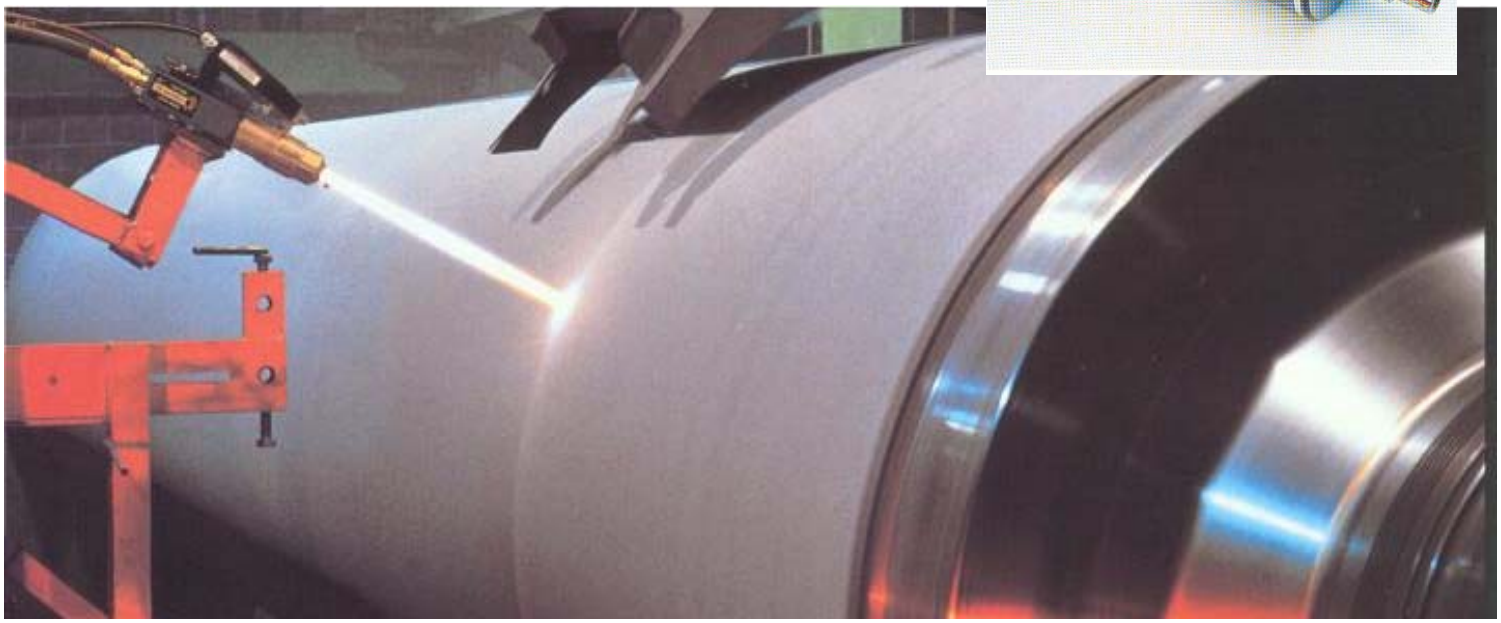
Plasma sprayed coatings on aircraft turbine engine parts



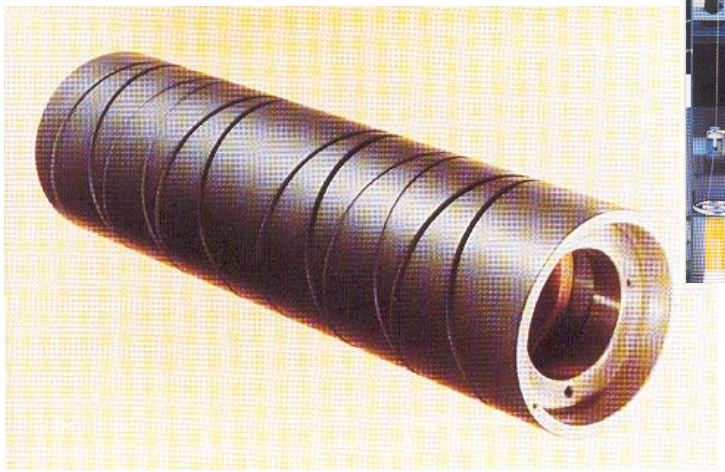
Courtesy of Sulzer Metco

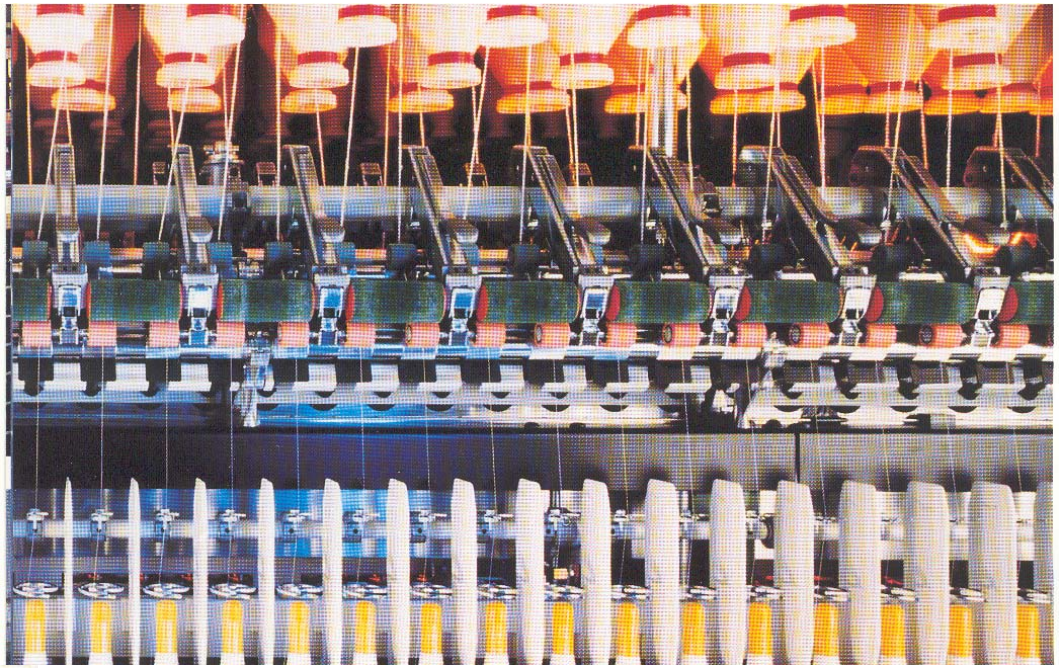
Plasma spray applications in the paper and Printing industry



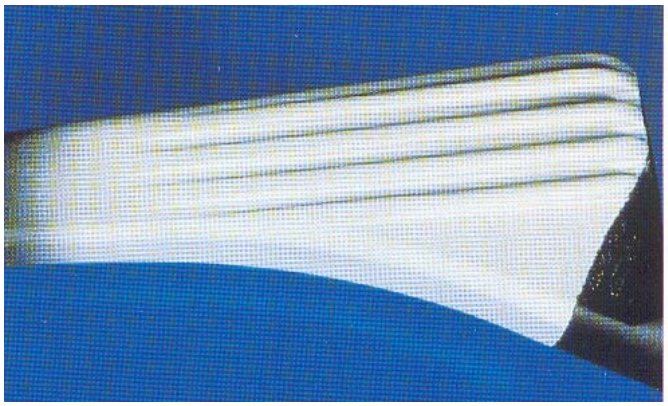


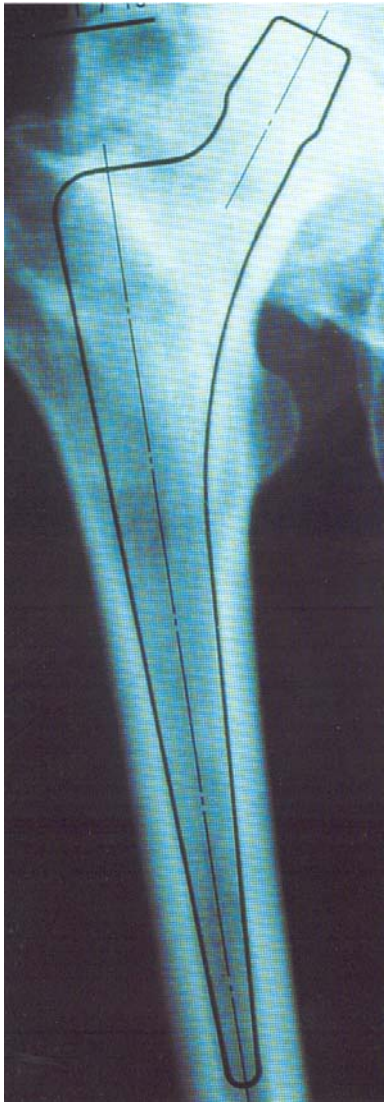
Applications of plasma spray technology for the coating of Spools and high wear parts in the textile industry



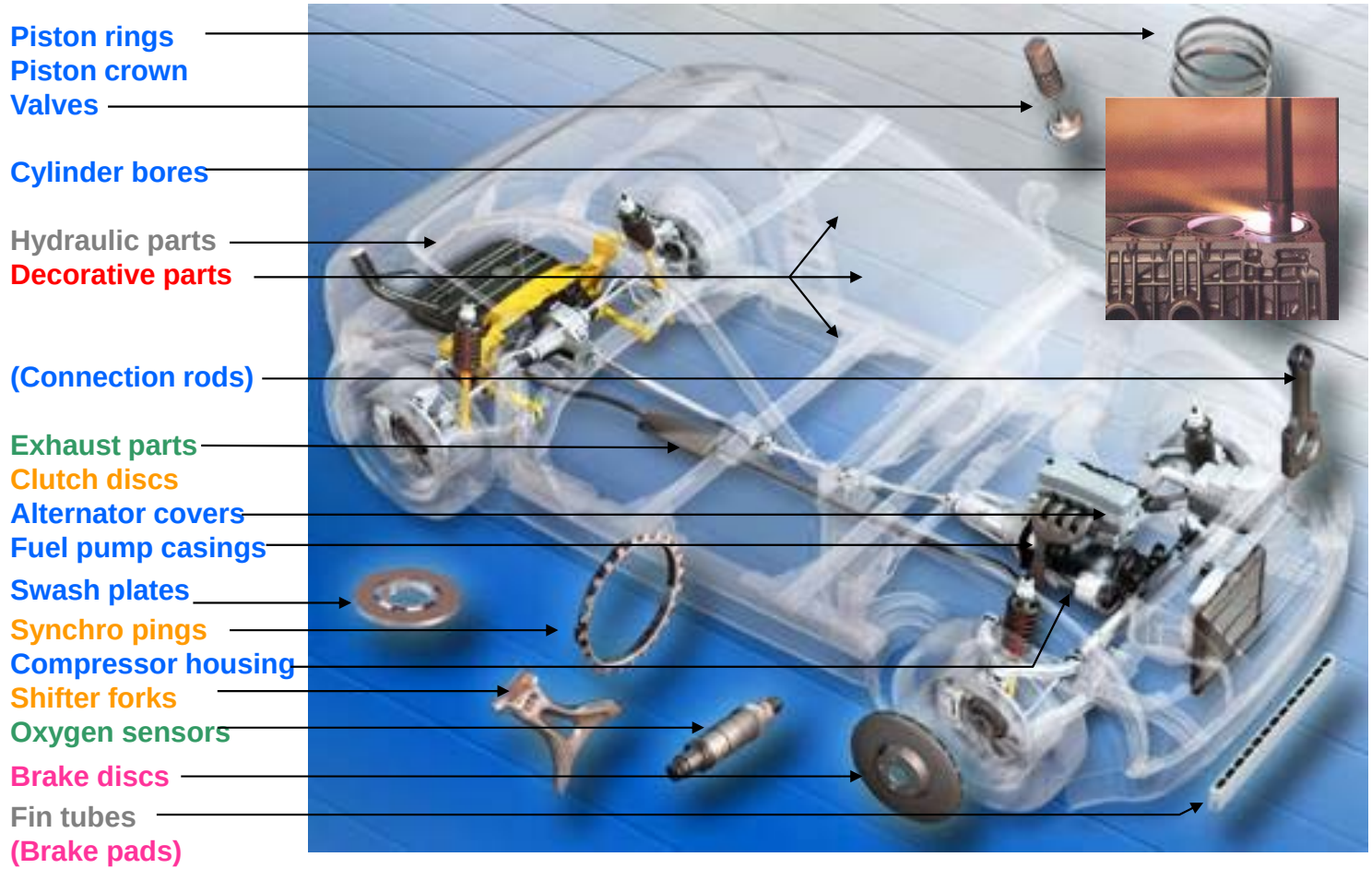


Medical applications of plasma spray technology for the coating of hip and dental implants



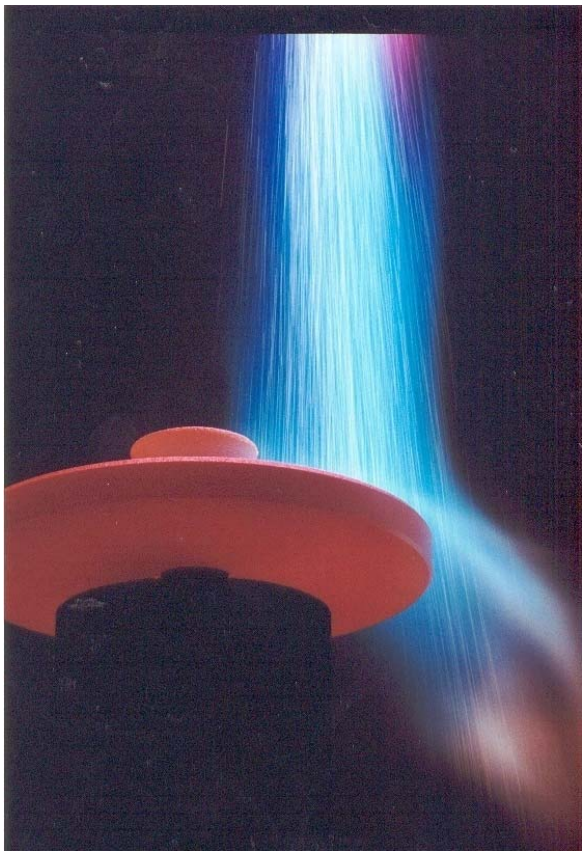


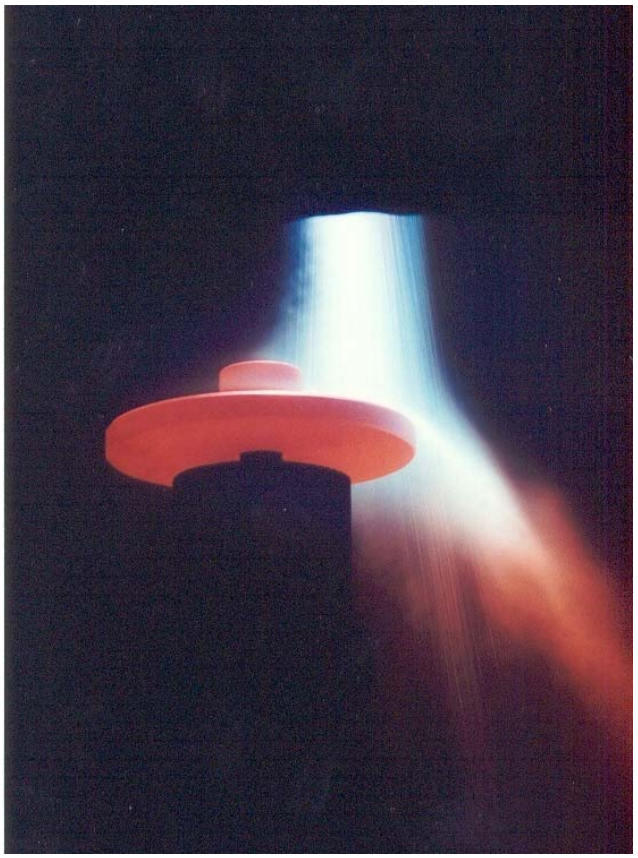
Thermal spray components in the automotive industry



Courtesy of Sulzer Metco

Induction plasma Vacuum Plasma Spraying (VPS)





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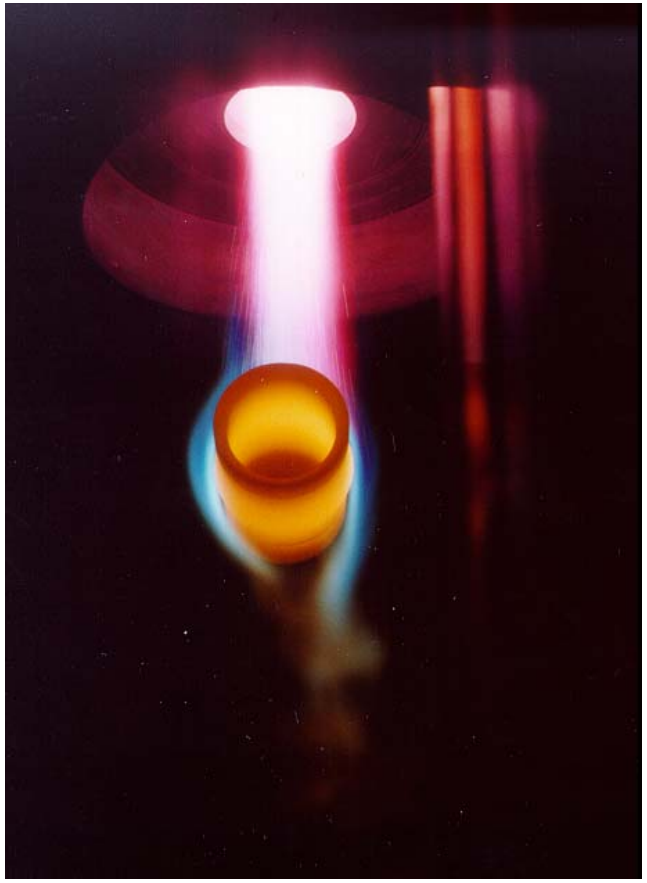
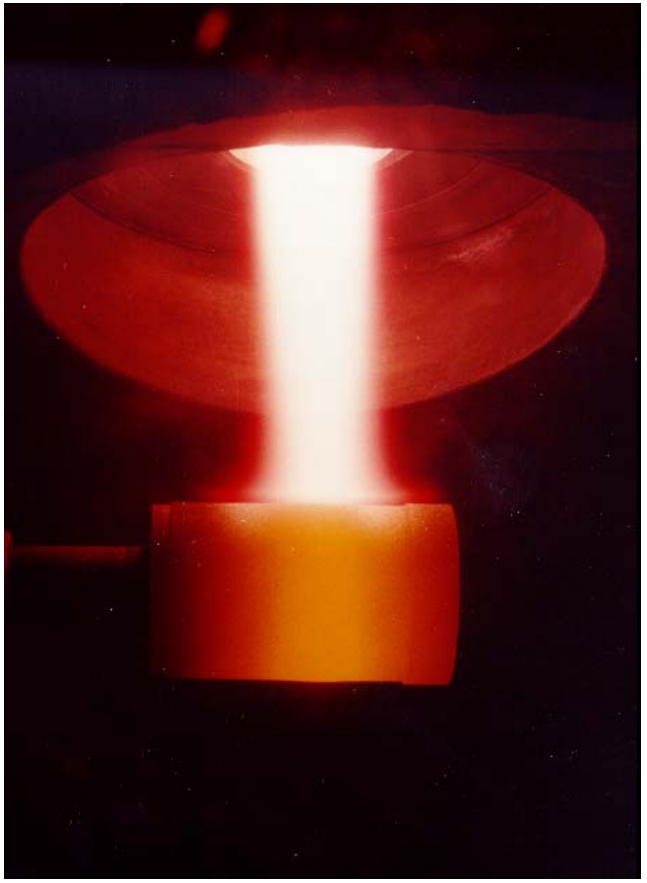


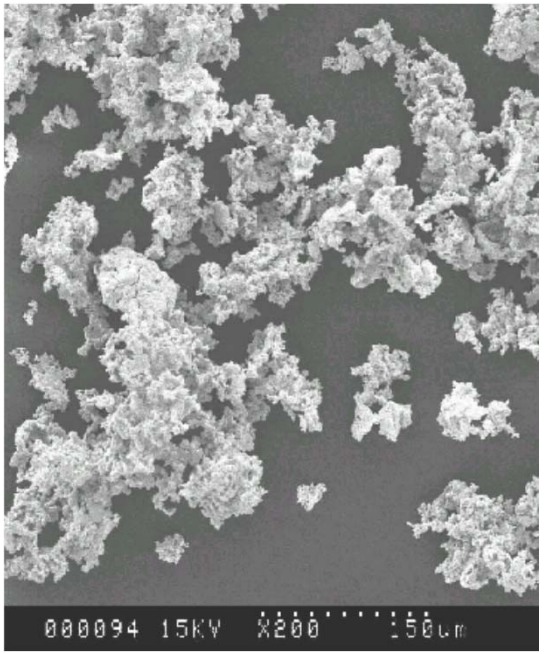


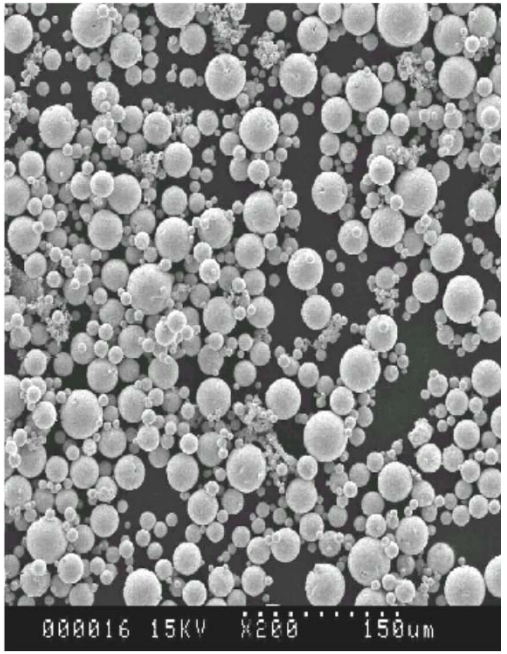
Induction plasma Vacuum Plasma Spraying (VPS)

Induction plasma treatment of powders

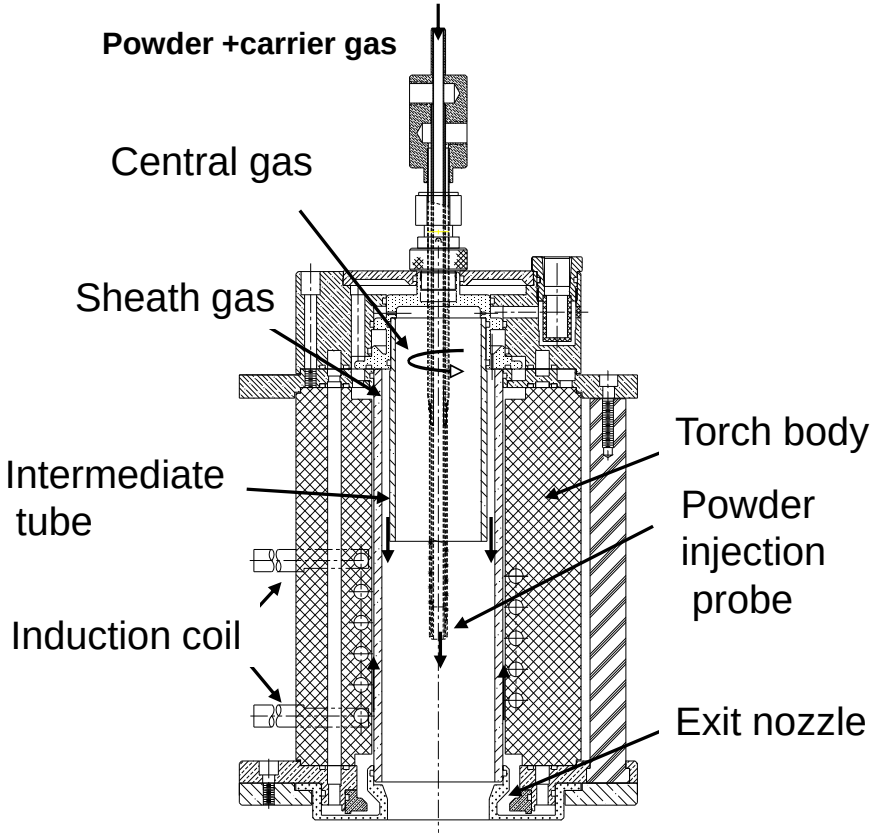
Objectives

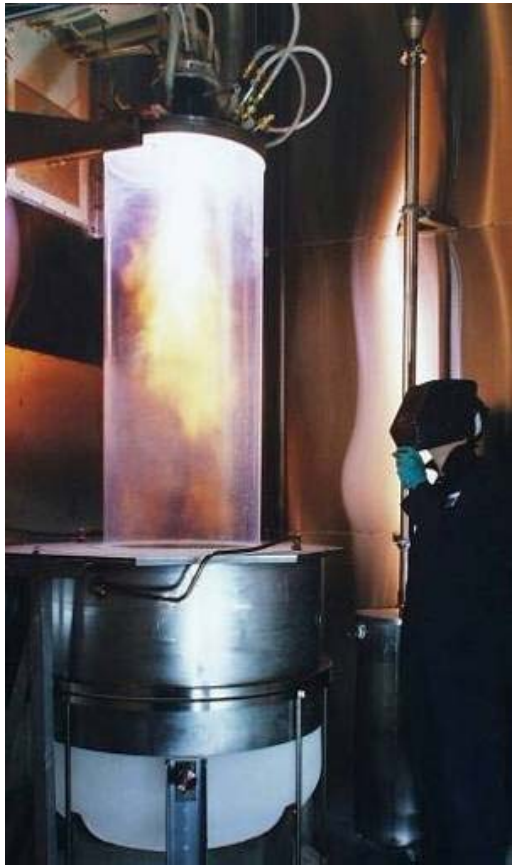
- ❑ Improve Flowability
- ❑ Lower Porosity
- ❑ Higher Powder Density
- ❑ Less Friable
- ❑ Less Abrasive
- ❑ Increase Purity





Induction plasma processing of powders at Tekna

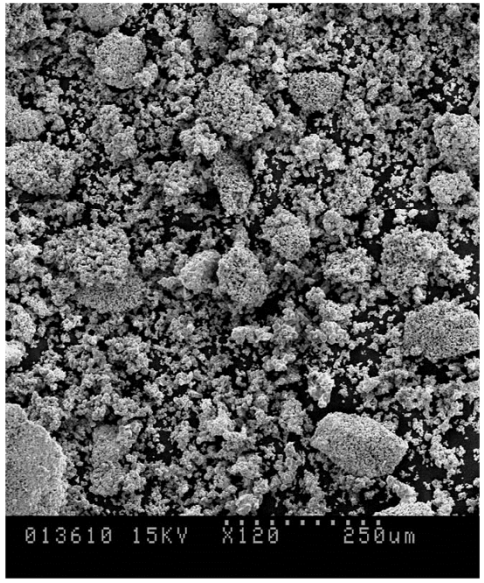
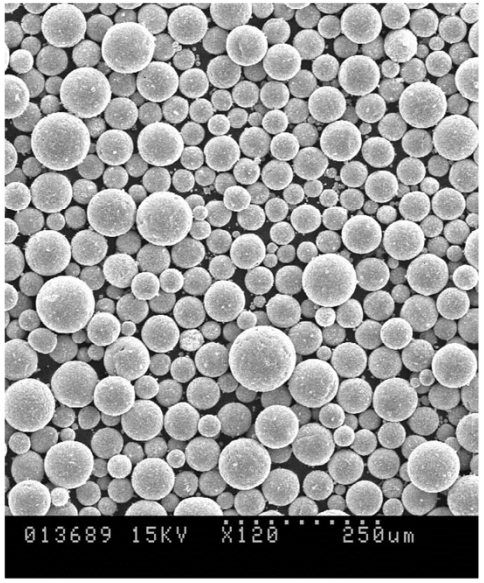




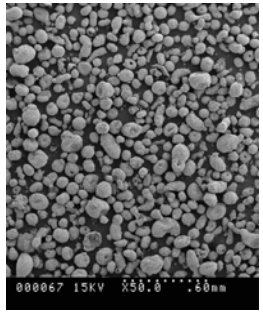
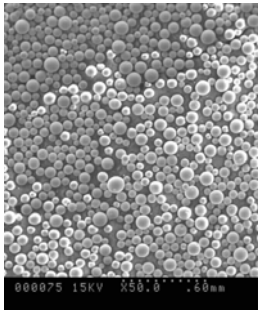
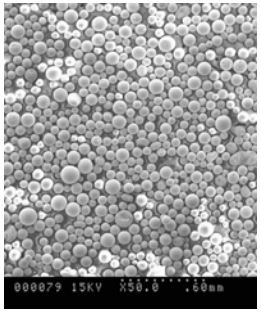
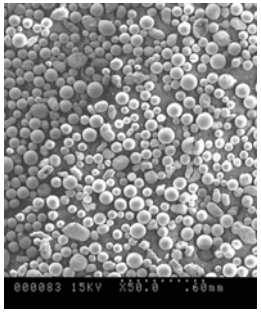
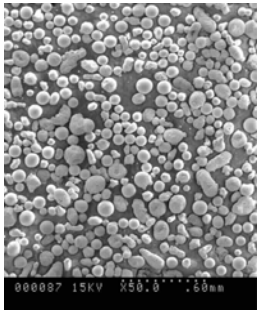
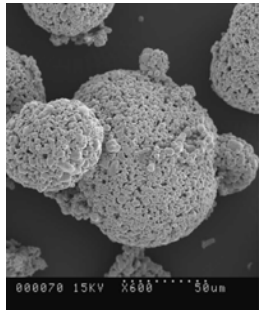
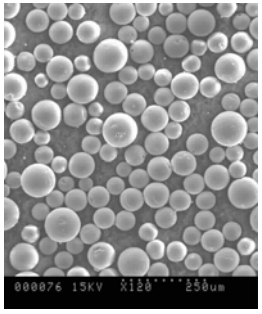
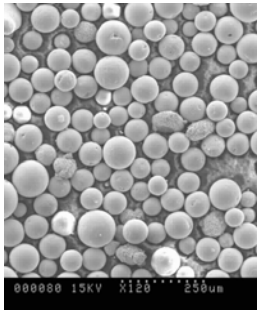
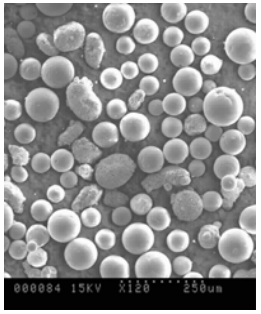
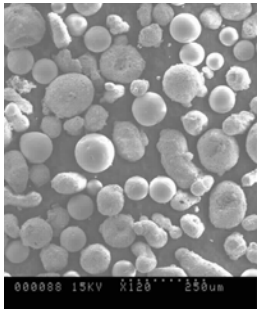
U.S. Patent # 5 200 595 and International PCT/CA92/00156

Molybdenum

Atomic Number:	42
Melting point:	**2623ºC**
Boiling point:	~4639ºC
Density:	10,22 g/cm^3
Heat Capacity:	0.255 J/gºC
Thermal conduct.:	138 W/m-K

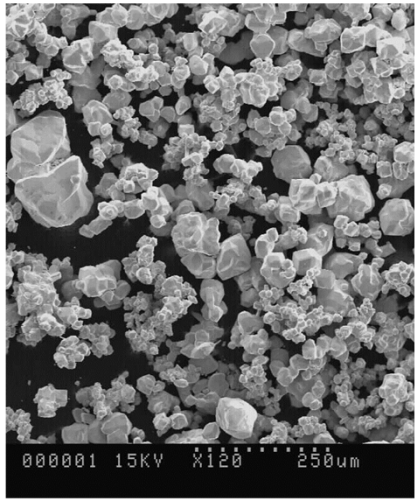
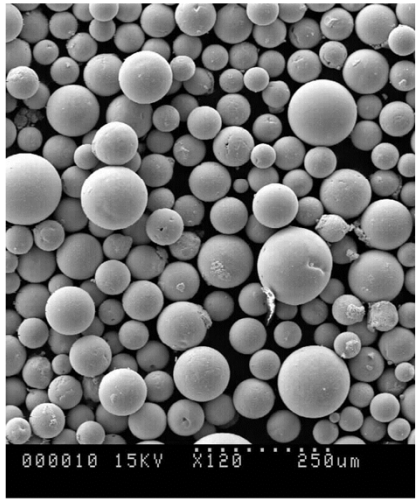
Properties	Before Plasma Treatment	After Plasma treatment
Tap Density	2,3 g/cm^3	6,6 g/cm^3
Purification Factor	N/A	N/A
Hal Flow Test	No Flow	13 sec/50g
Degree of Spheroidization		

Molybdenum

	7kg/h	14kg/h	20kg/h	25kg/h
				
				
Tap Density : 3.2 g/cc	**6.35 g/cc**	**6.25 g/cc**	**5.8 g/cc**	**5.0 g/cc**
Hall Flow 50g : 36 s	**13.0 s**	**14 s**	**16 s**	**19 s**

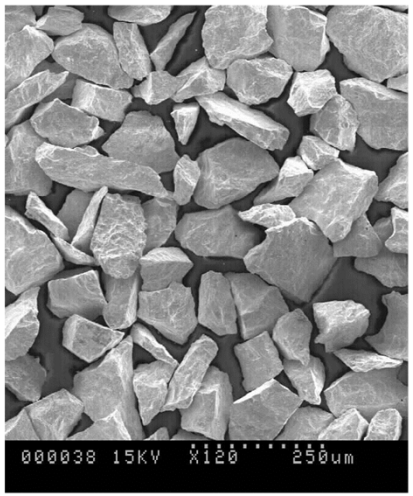
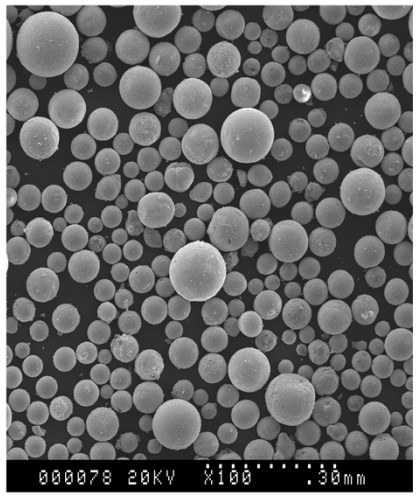
Tungsten

Atomic Number:	74
Melting point:	**3410°C**
Boiling point:	5700°C
Density:	19,3 g/cm^3
Heat Capacity:	0,134 J/g-° C
Thermal conduct.:	163,3 W/m-K

Properties	Before Plasma Treatment	After Plasma treatment
Tap Density	7,5 g/cm^3	11,7 g/cm^3
Purification Factor	N/A	N/A
Hal Flow Test	No Flow	7 sec/50g
Degree of Spheroidization		

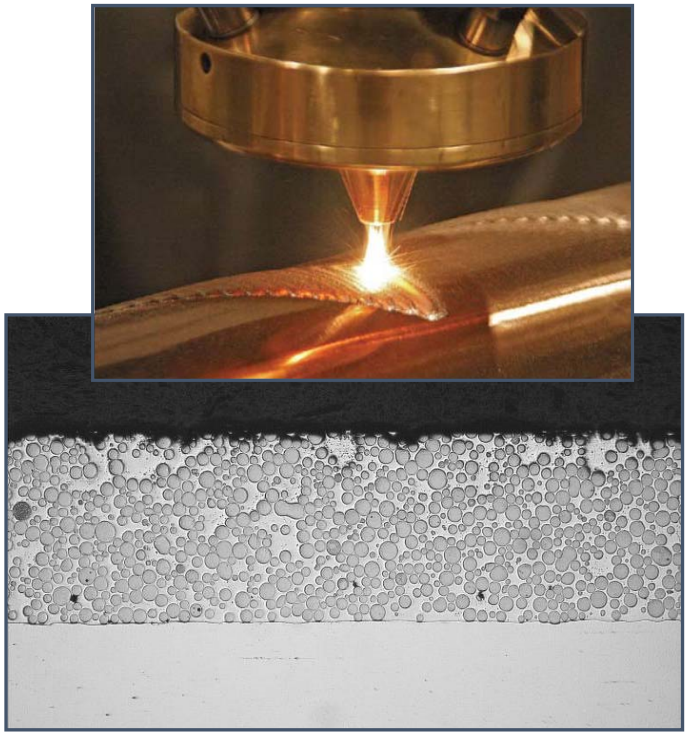
Tungsten Carbide

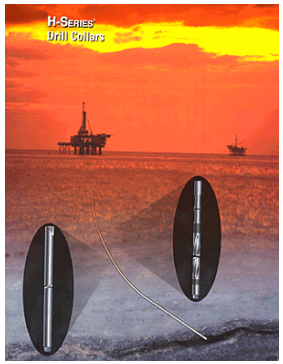
Chemical Formula:	**WC**
Molecular Weigh:	**195,9**
Melting point:	**~2800ºC**
Boiling point:	**~6000ºC**
Density:	**15,7 g/cm^3**
Crystal Structure:	**Hexagonal**
Color:	**Gray**

Properties	Before Plasma Treatment	After Plasma treatment
Tap Density	8,1 g/cm^3	10,2 g/cm^3
Purification Factor	N/A	N/A
Hal Flow Test	19 sec/50g	7 sec/50g
Degree of Spheroidization		

Spherical Cast WC Powder

Mixed with Nickel alloys, then coated on steel parts to prevent wear and corrosion



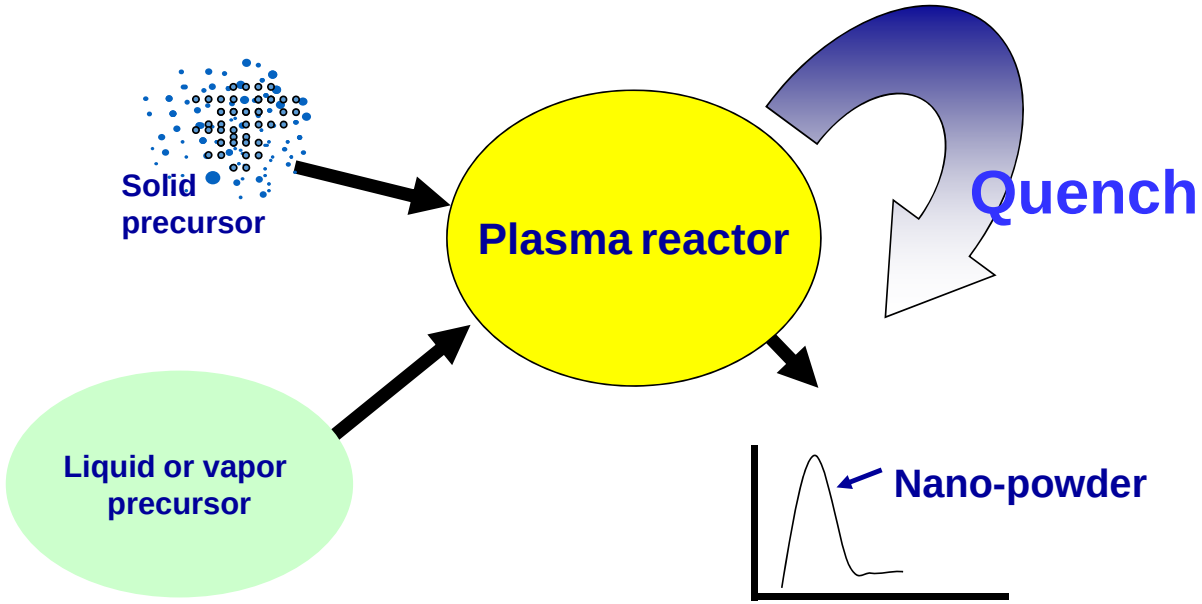


Drill bits

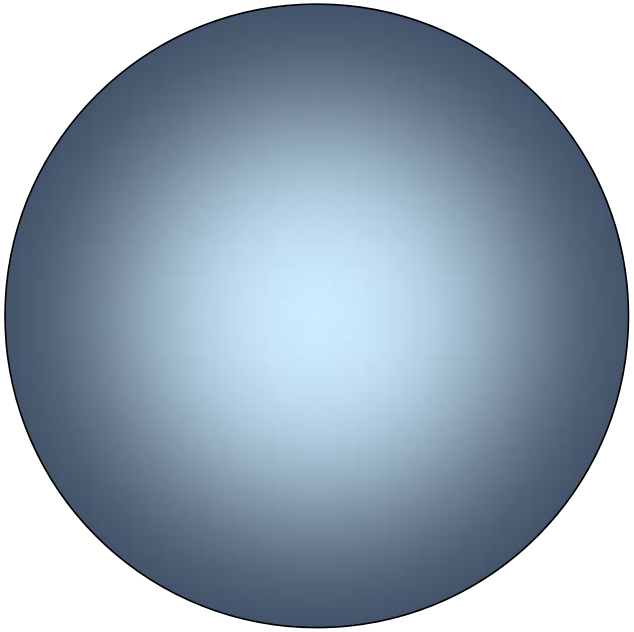
OD Protectors

Tool joints

Plasma synthesis of nano-powders



Plasma synthesis of nano-powders



1 µm, 6m^2/g

100 nm, 60m^2/g

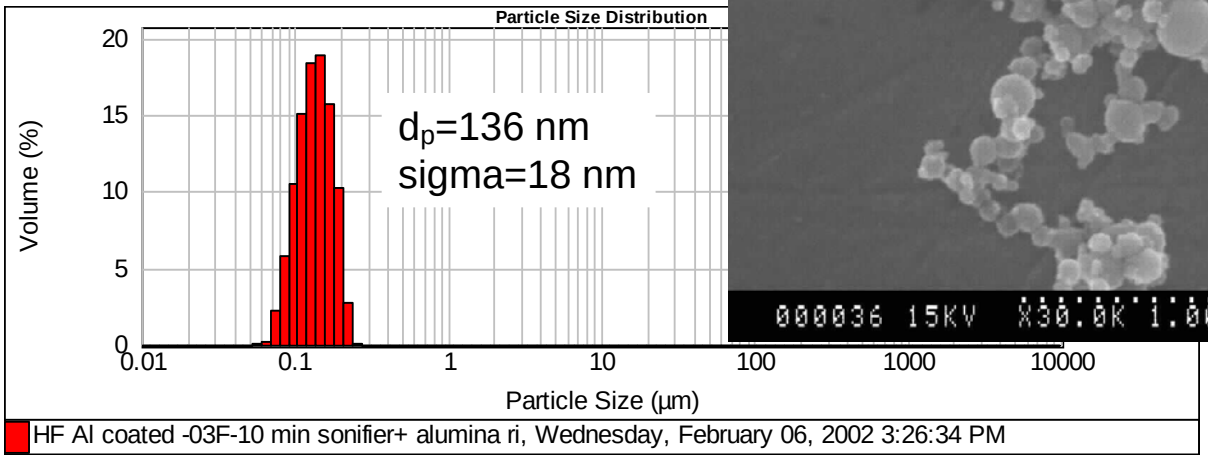
10nm, 600m^2/g

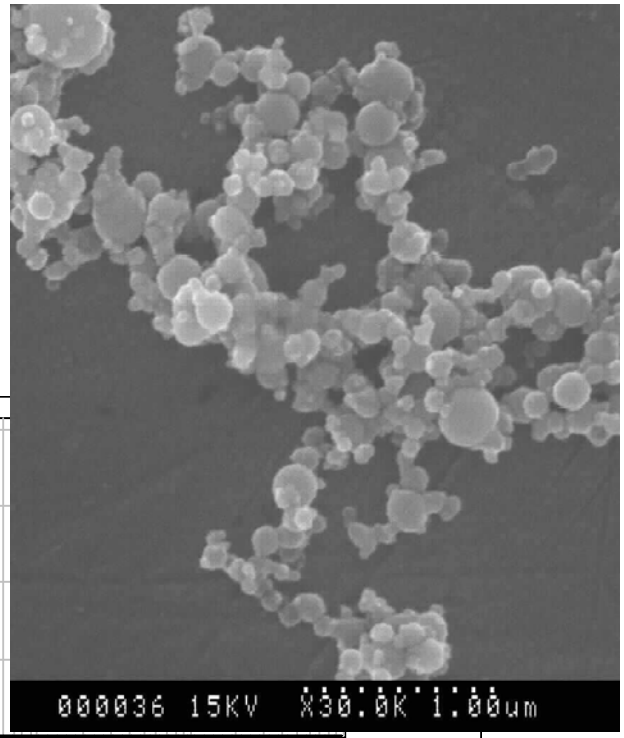
60kW nanopowder synthesis at Tekna

Synthesis of Aluminum nanopowder

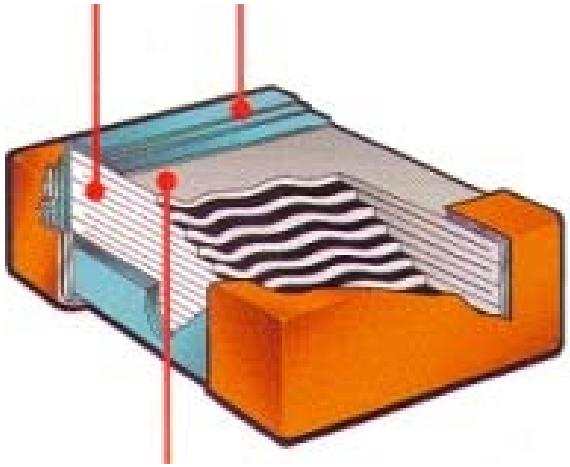
BET = 17.2 m^2/g

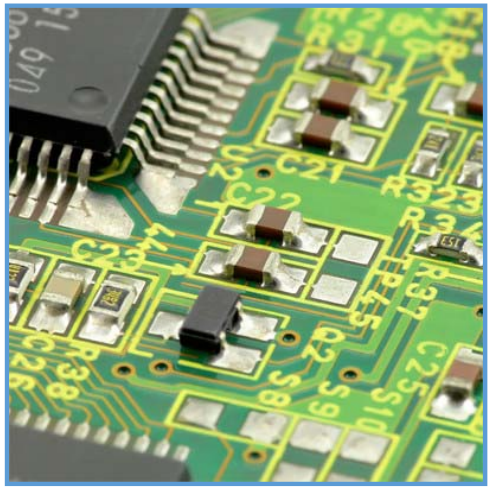
d_p mean= 130 nm

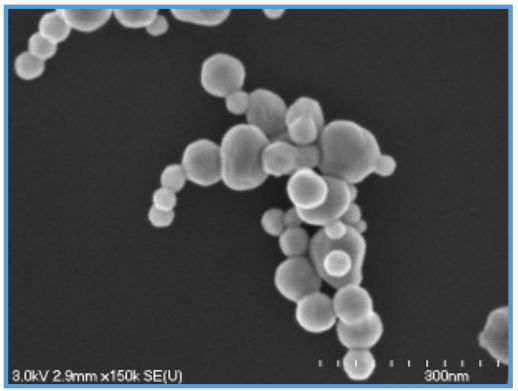


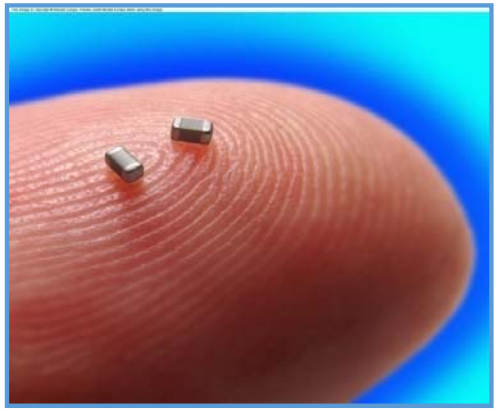


Nanopowders in the electronic industry

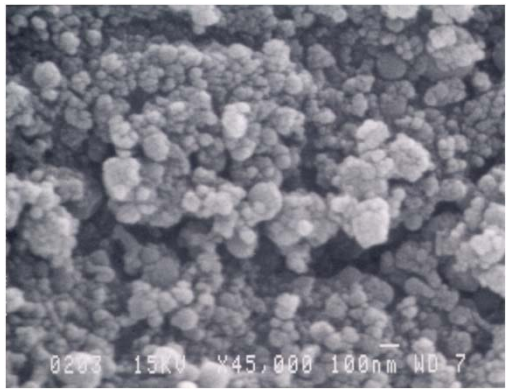


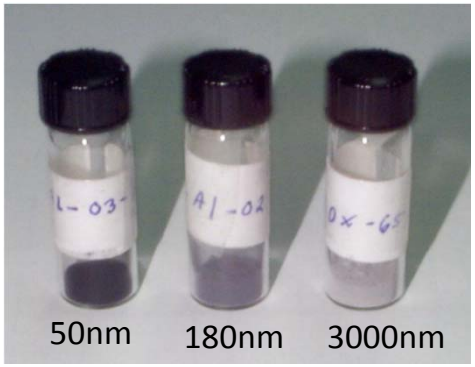


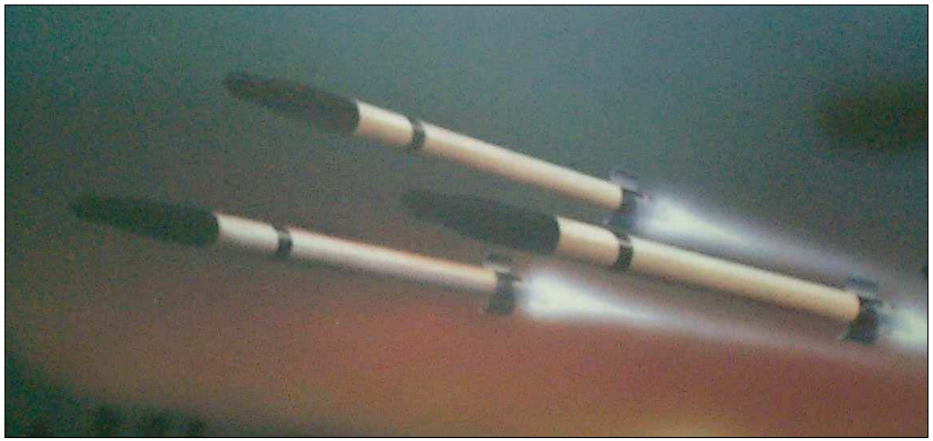




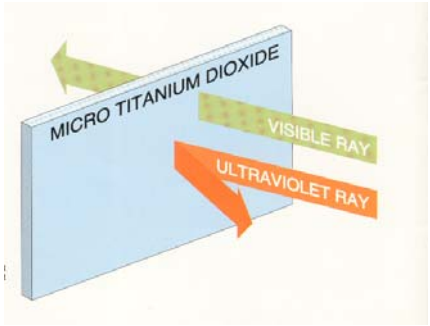
Aluminum nanopowders as energetic materials







Nanopowders applications in the sun-screen industry



Run #29 TiO2
Sp= 25.4 m2/g
dp (BET)= 60 nm
dp (PCS)=31.2 nm
Xa = 85%

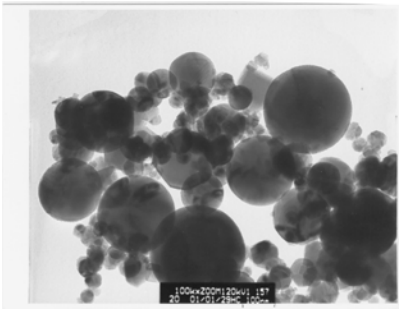
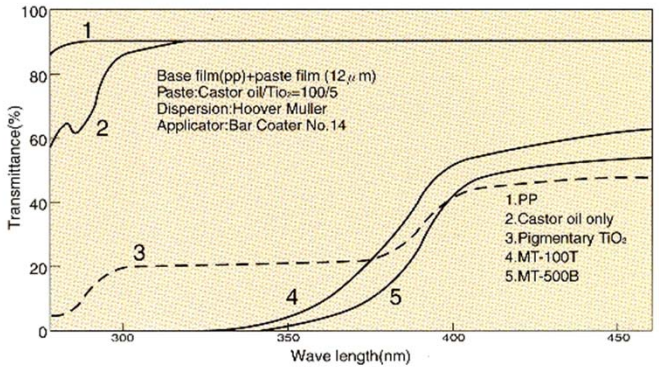


Fig.1 - Light Transmission Curves



Sommaire et conclusions

La technologie des plasmas thermiques a évolué au cours des cinquante dernières années d'une technologie réservée au secteur de l'aerospaciale à des applications civiles telle que;

- La coupe et la soudure des métaux.
- Le revêtement et la fabrication de pièces de forme.
- Le traitement et la synthèse de poudres sphériques.
- La synthèse des nanopoudres pour diverses applications dans les domaines de la microélectronique, de l'énergie, et de la santé.

Merci / Thank you