

# Nízkoteplotná plazma v medicíne

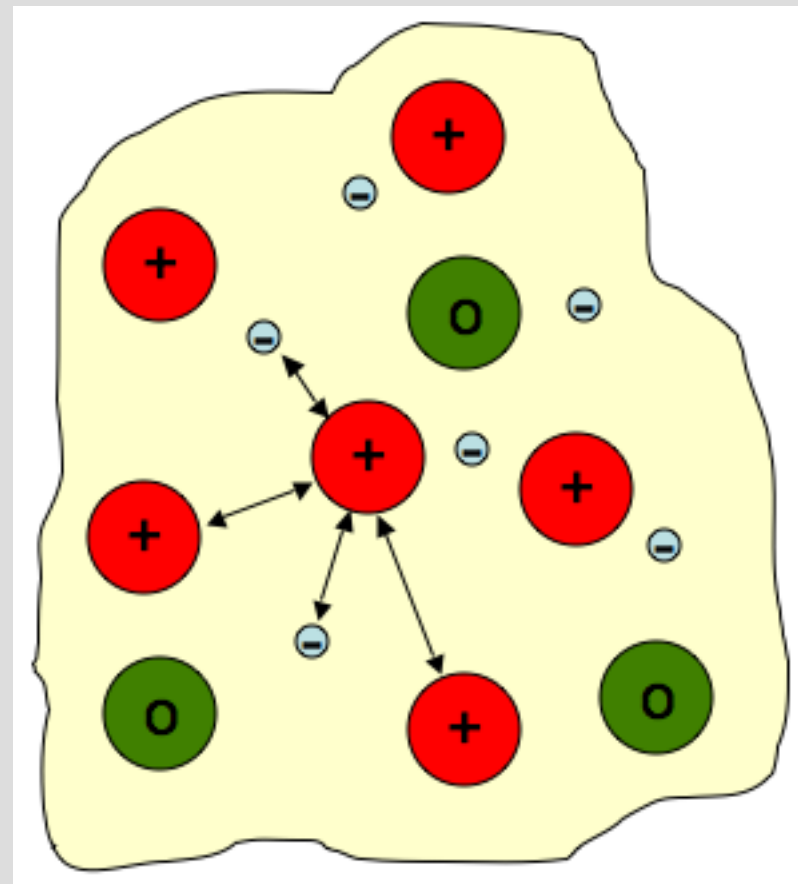
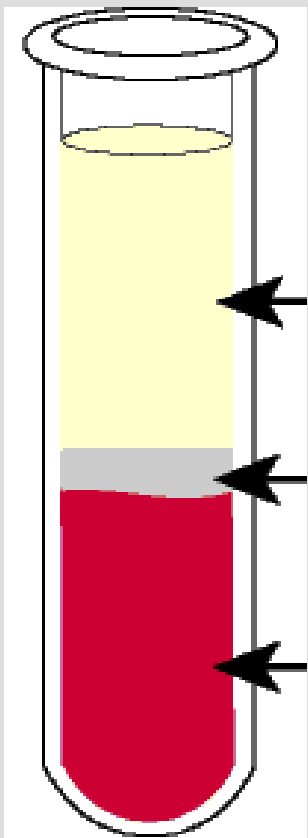
## Vladimír Scholtz



# Vladimír Scholtz

- 1992 – 1996 – GJH
- 1996 – 2003 – FEI STU + GJH
- 2003 – 2006 – FEL ČVUT
- 2006 – 2007 – FEI STU
- 2007 – 2013 – VŠCHT

# Čo je plazma?

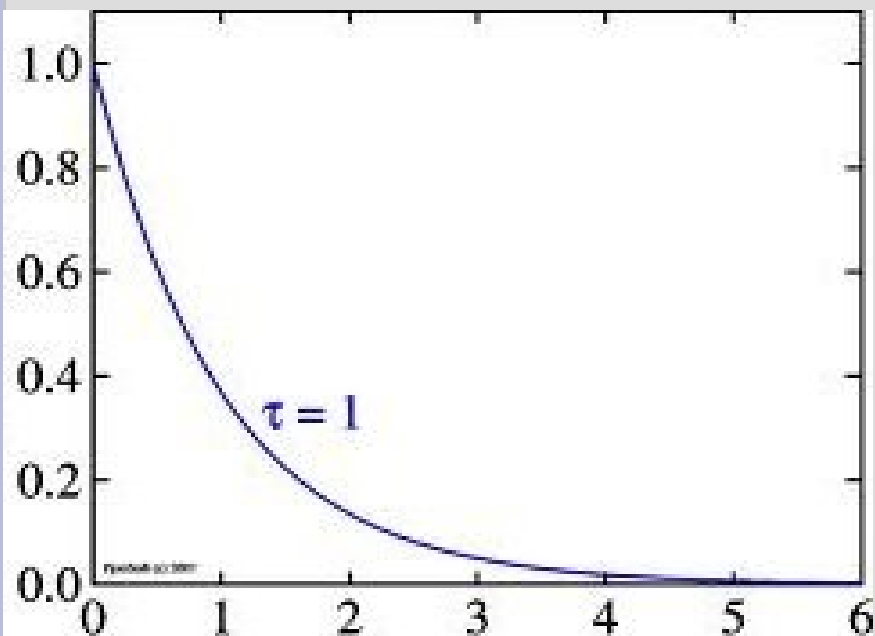


# Čo je plazma?

- 4. „skupenstvo“ hmoty
- Ionizovaný plyn
- Zmes nabitých a neutrálnych častíc
- Celkový náboj nulový

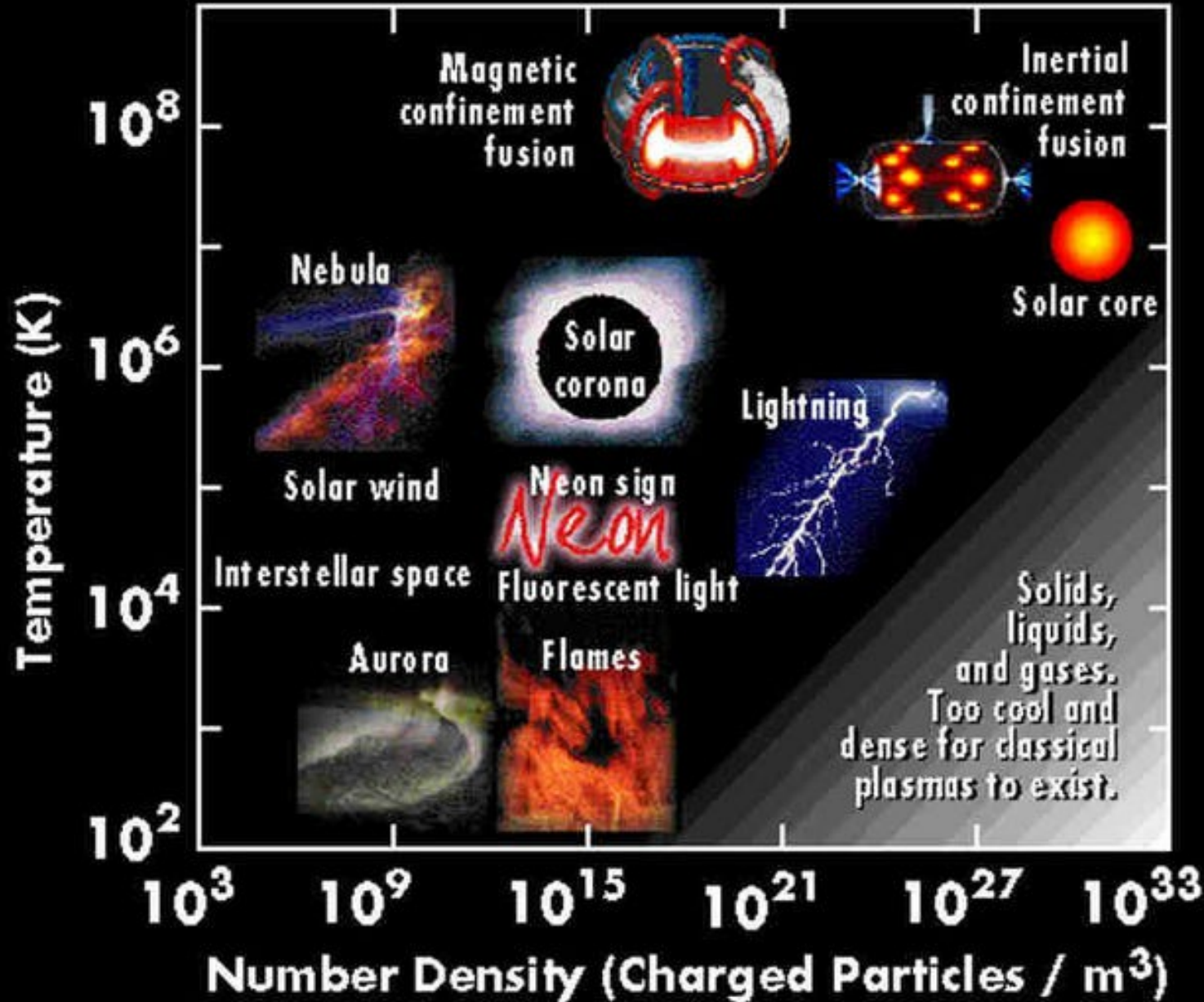
# Čo je plazma?

- Debyeovo tnenie
- Počet častíc
- Interakcie nabitých a neutrálnych častíc

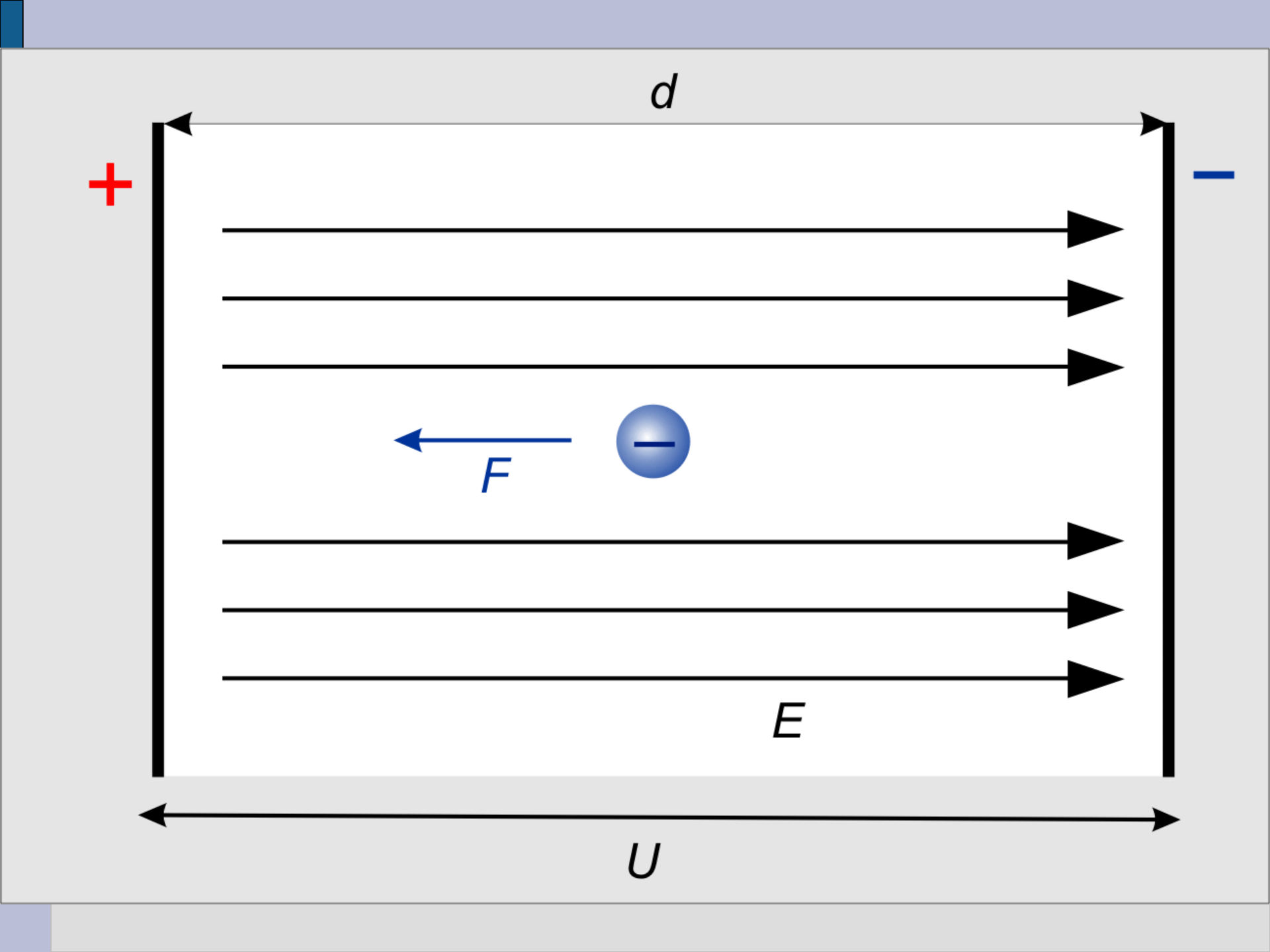


# Vznik plazmy

- **Termálna**
- Zahriatie na vysokú teplotu  
(Slnko, tokamak, ...)
- **Netermálna**
- Energia dodávaná iba elektrónom  
(Elektrické výboje)

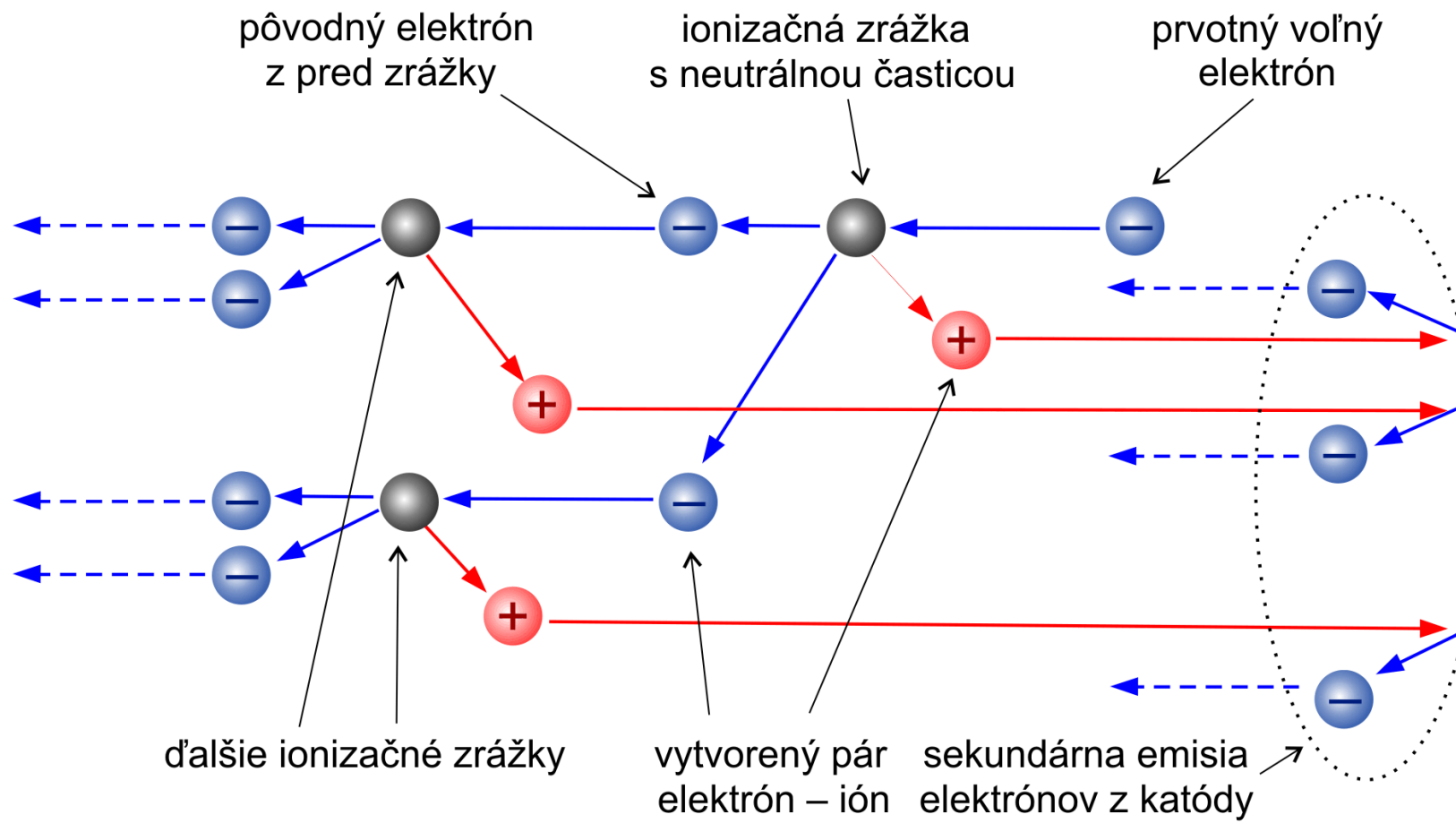


Copyright 1996 Contemporary Physics Education Project.  
 Images courtesy of DOE fusion labs, NASA, and Steve Albers.



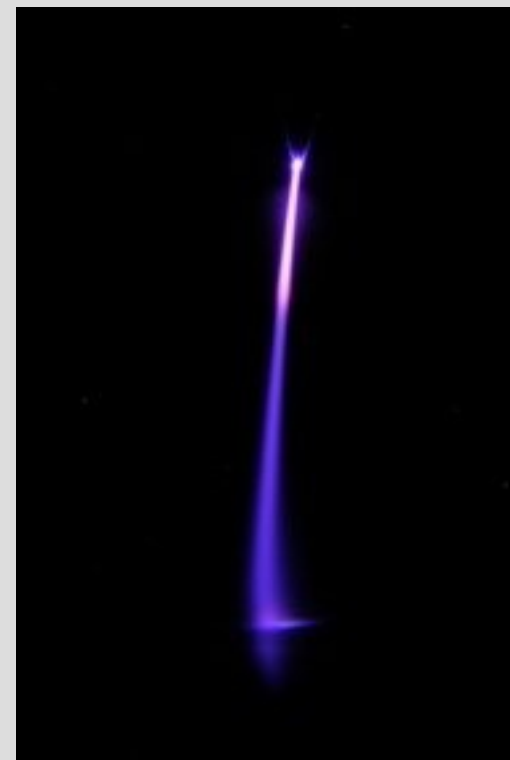
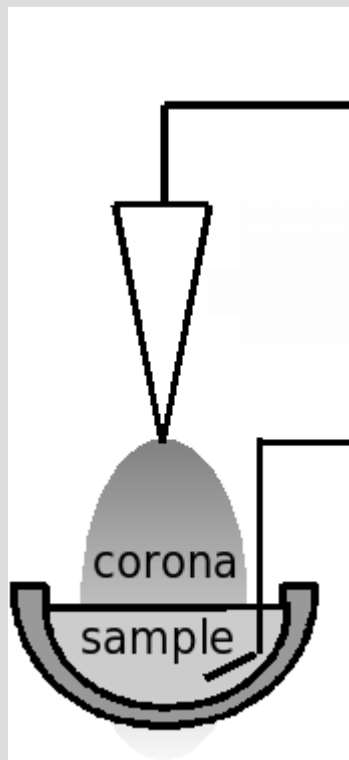


+



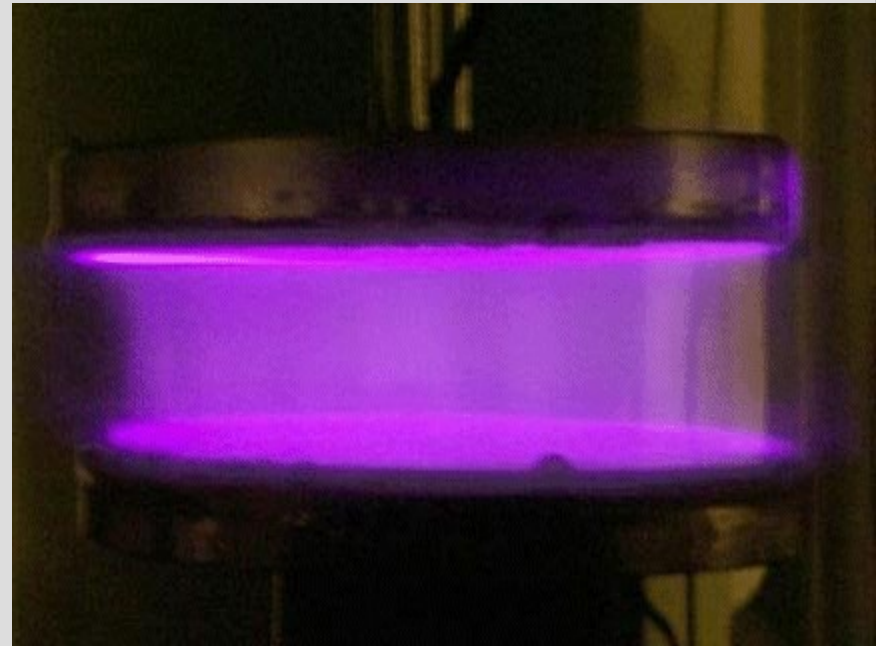
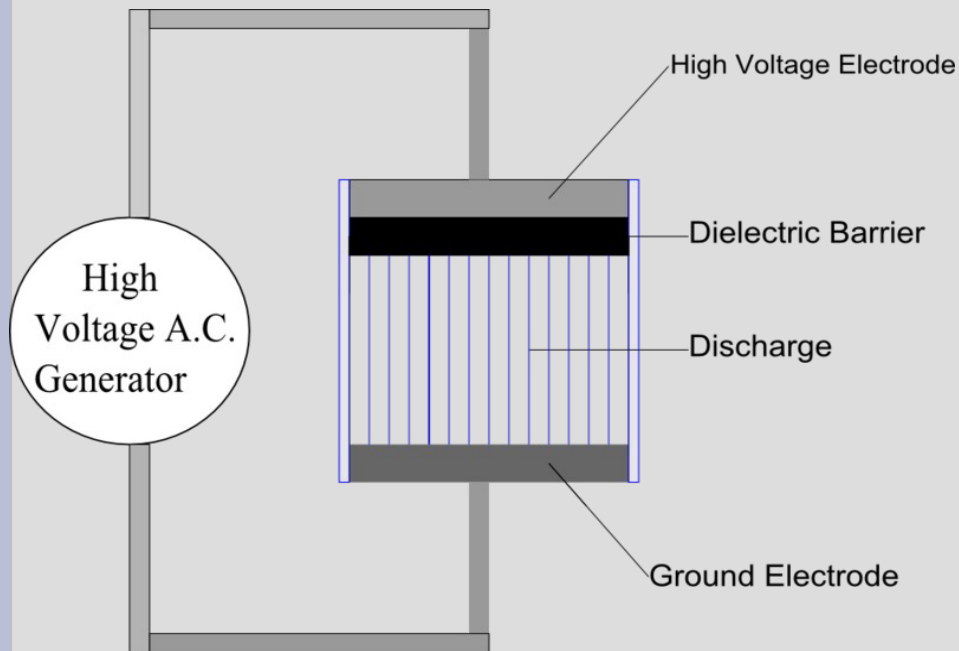
# Nízkoteplotná plazma z elektrických výbojov

- Korónový výboj



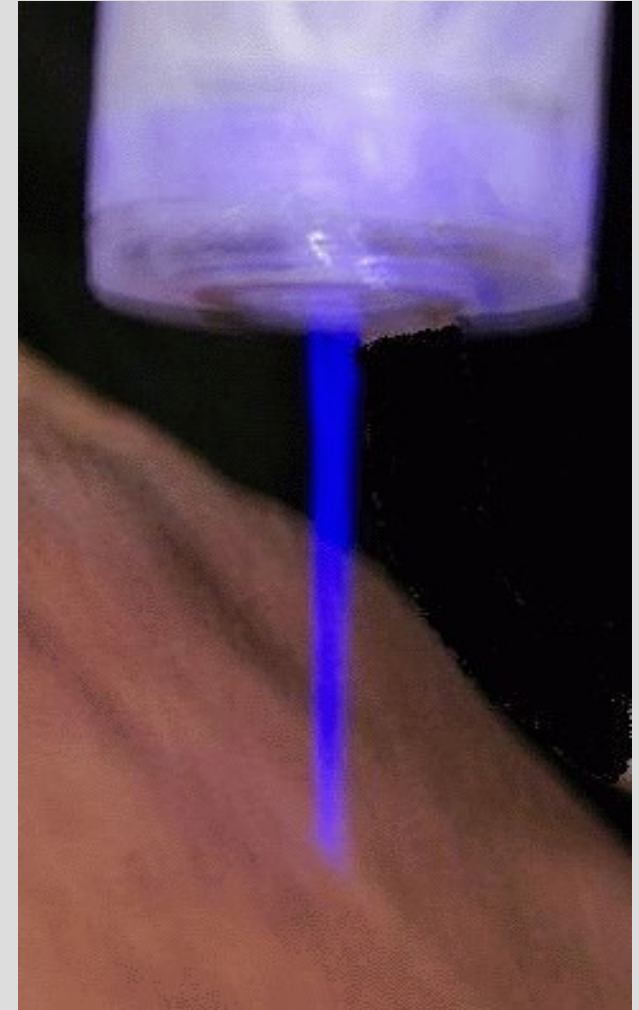
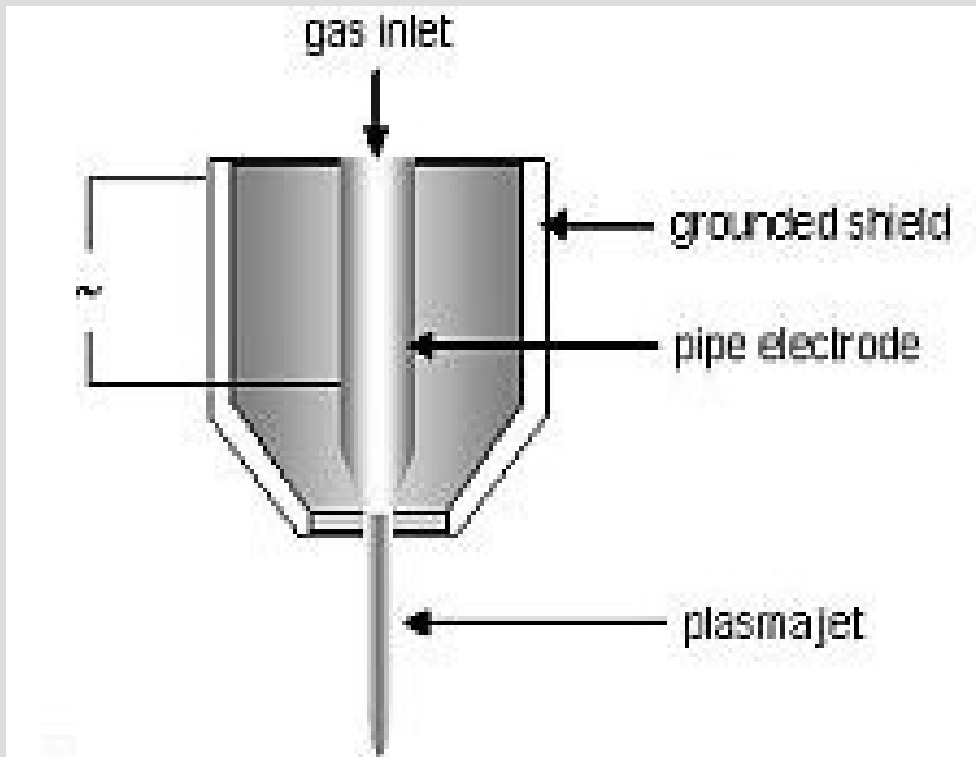
# Nízkoteplotná plazma z elektrických výbojov

- Dielektrický bariérový výboj



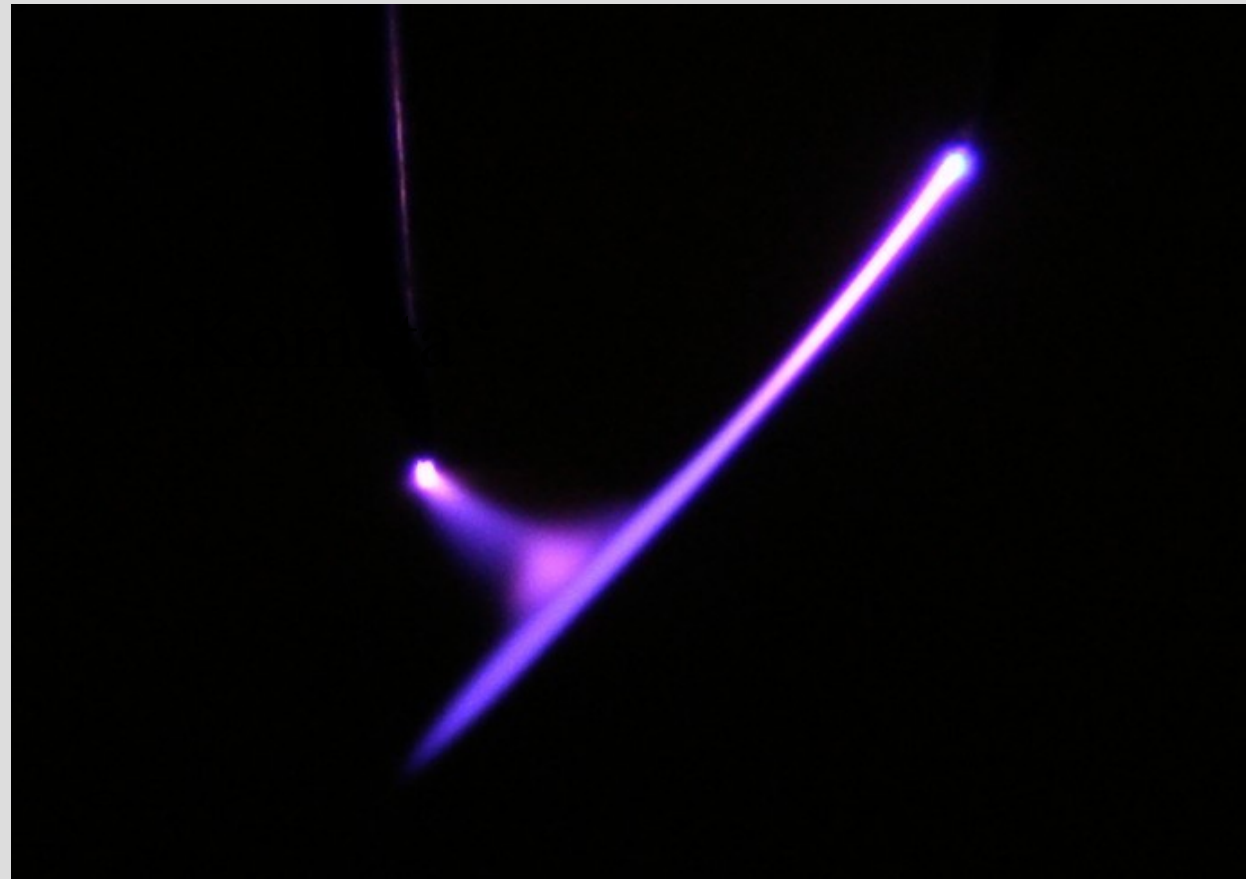
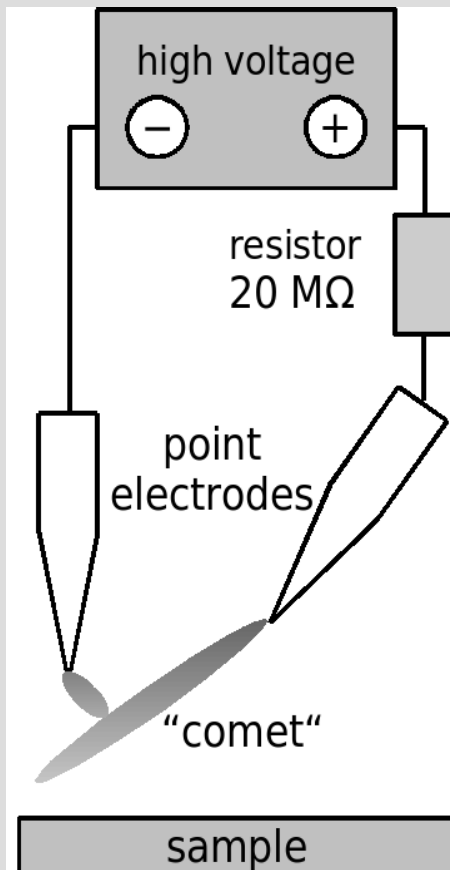
# Nízkoteplotná plazma z elektrických výbojov

- Plasmajet



# Nízkoteplotná plazma z elektrických výbojov

- Kometárny výboj



# Prečo plazma

- plazma nezvyšuje teplotu dekontaminovaného materiálu
- náklady sú nízke
- neznečisťuje povrch chemicky agresívnymi látkami
- pri aplikácii na väčšinu materiálov nezpôsobuje ich degradáciu
- pri aplikácii nevznikajú nežiadúce vedľajšie produkty
- odpadá problém s jej skladovaním



# Prvý krát

Moanir Laroussi

M. Laroussi: "Sterilization of Contaminated Matter with an Atmospheric Pressure Plasma", IEEE Trans. Plasma Sci., Vol.24, No.3, pp. 1188-1191, **1996**.

# Mechanizmy

- UV – tymínové dimery, nie je dominantný
- Reaktívne častice – kyslíkové č., NO<sub>x</sub>, OH<sup>·</sup>
- Nabité častice – kumulácia na povrchu
- Ozón, peroxid, ...

M. Laroussi, "Low Temperature Plasma-Based Sterilization: Overview and State-of-the-Art", Plasma Proc. Polym., Vol. 2, No. 5, 2005.

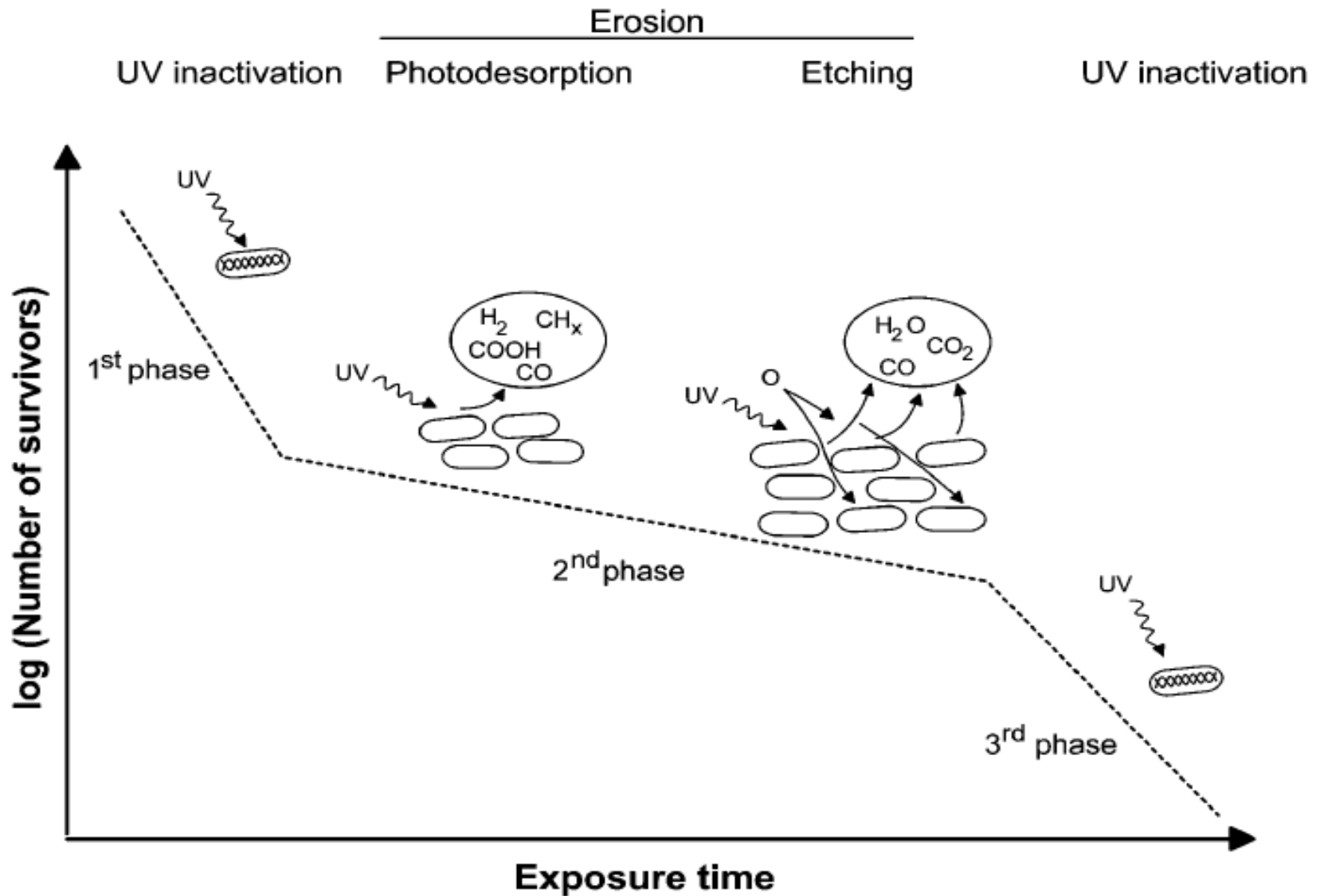


(a)



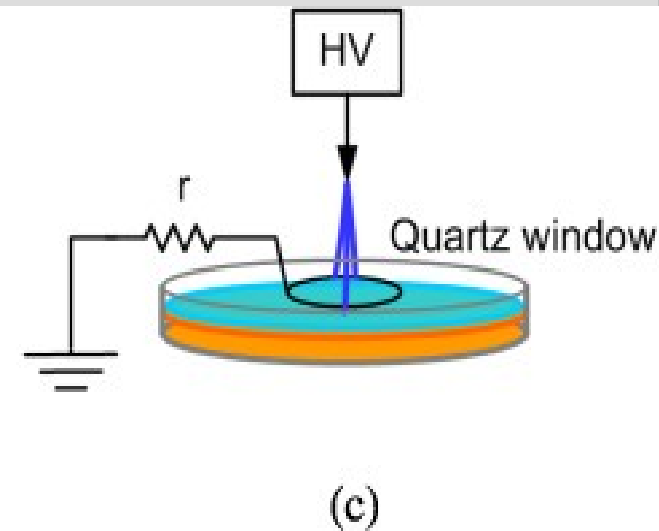
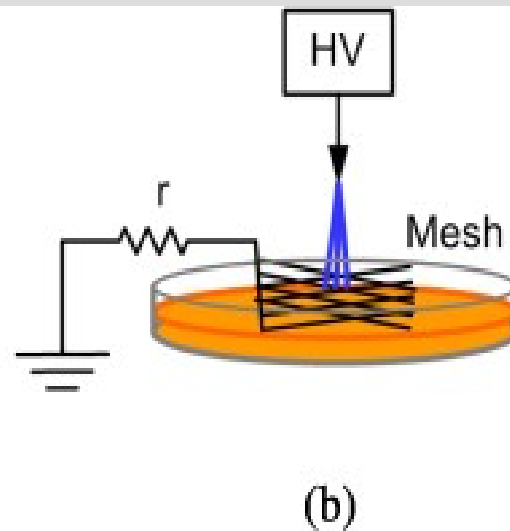
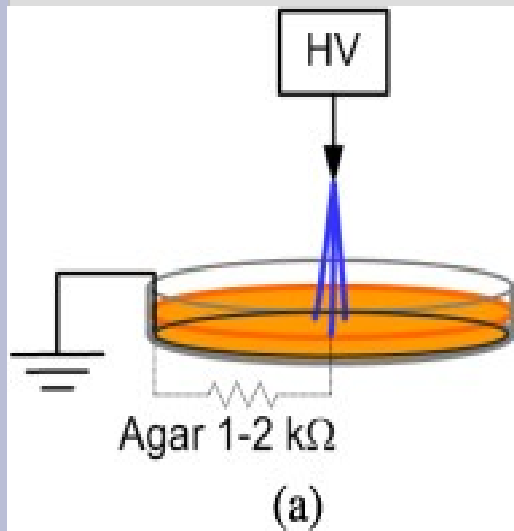
(b)





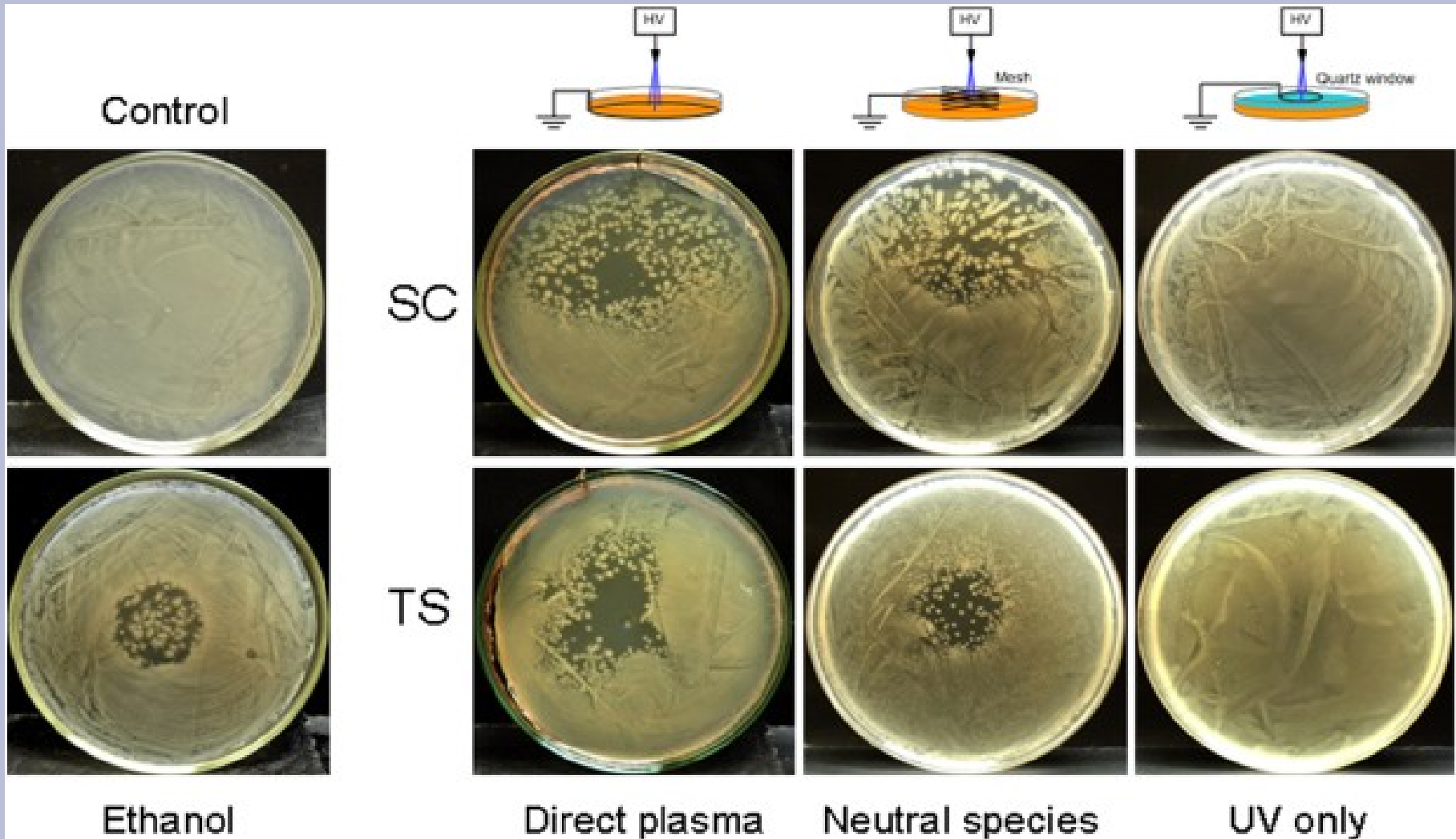
M. Moisan, J. Barbeau, M.-C. Crevier, J. Pelletier, N. Philip, B. Saoudi, Plasma sterilization: methods and mechanisms, Pure and Applied Chemistry (IUPAC), 74, 349-358.

# Mechanizmy



Plasma agents in bio-decontamination by dc discharges in atmospheric air. Zdenko Machala et al 2010 J. Phys. D: Appl. Phys. 43 222001

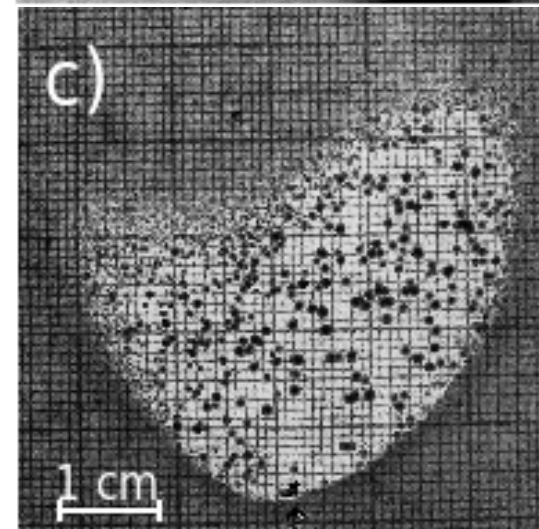
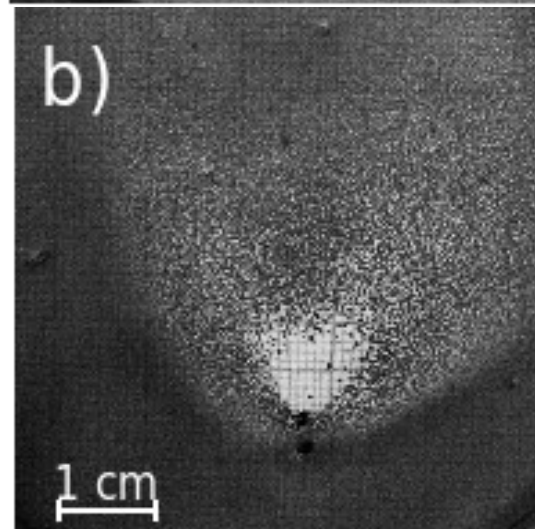
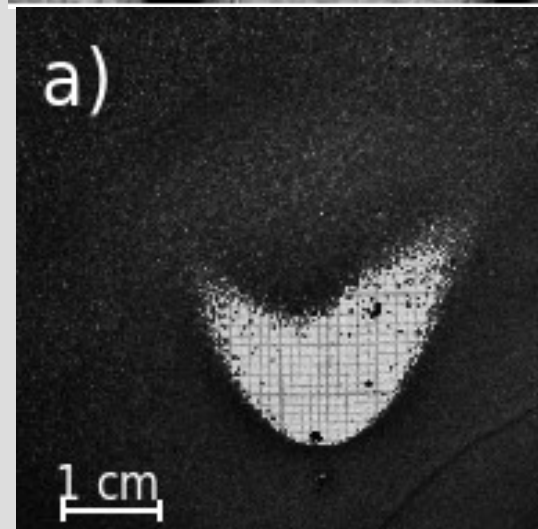
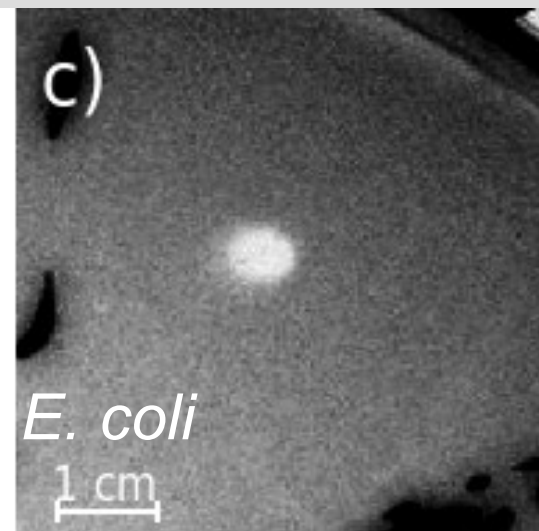
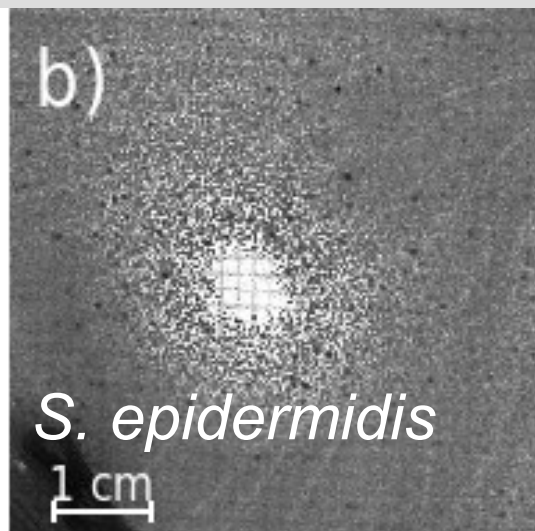
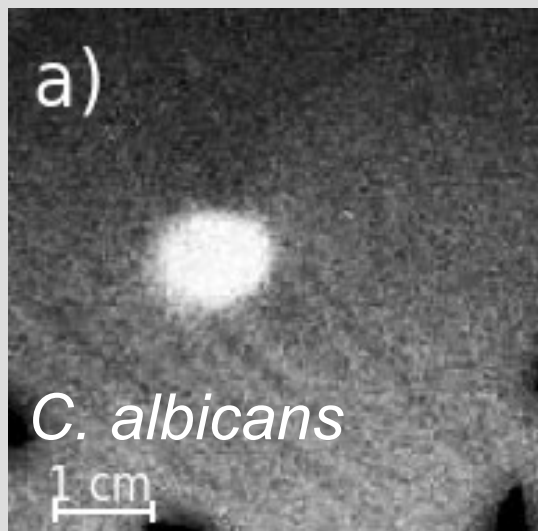
# Mechanizmy



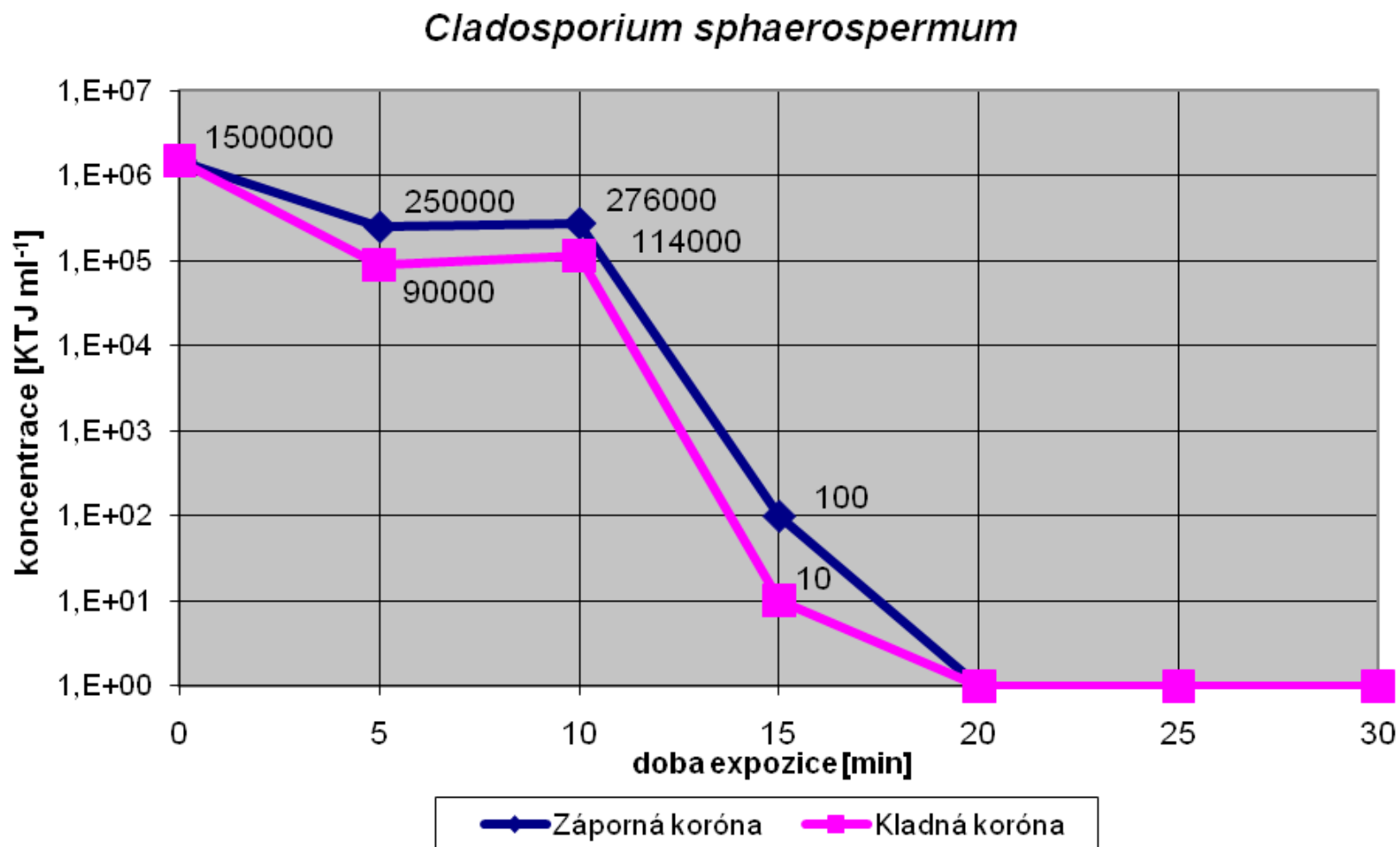
# Aplikace

- bio dekontaminácia, sterilizácia
- bezpečnosť potravín
- medicínske aplikácie
- Fridmani

# Dekontaminácia povrchov

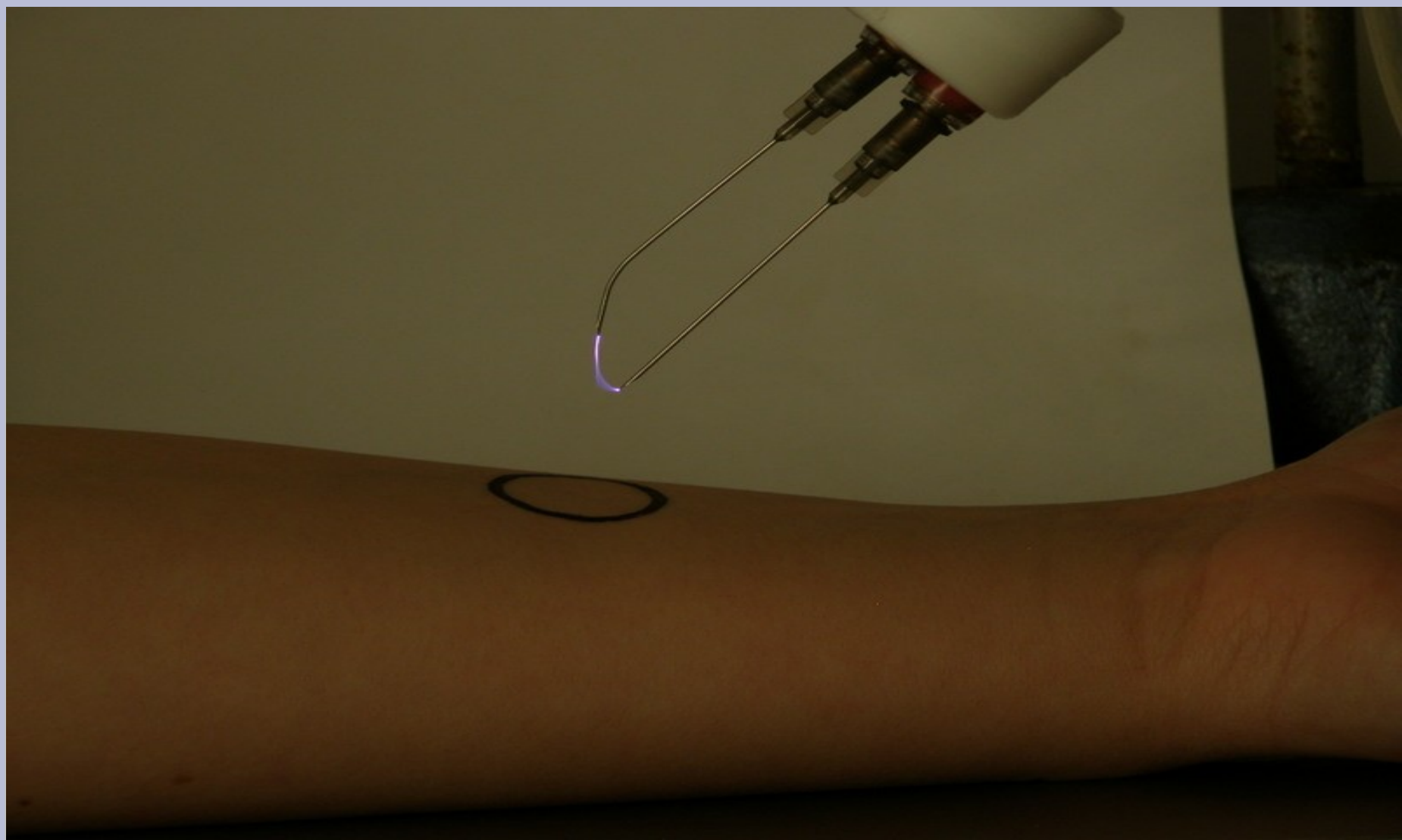


# Dekontaminácia kvapalín





# „Koméeta“ na kožu

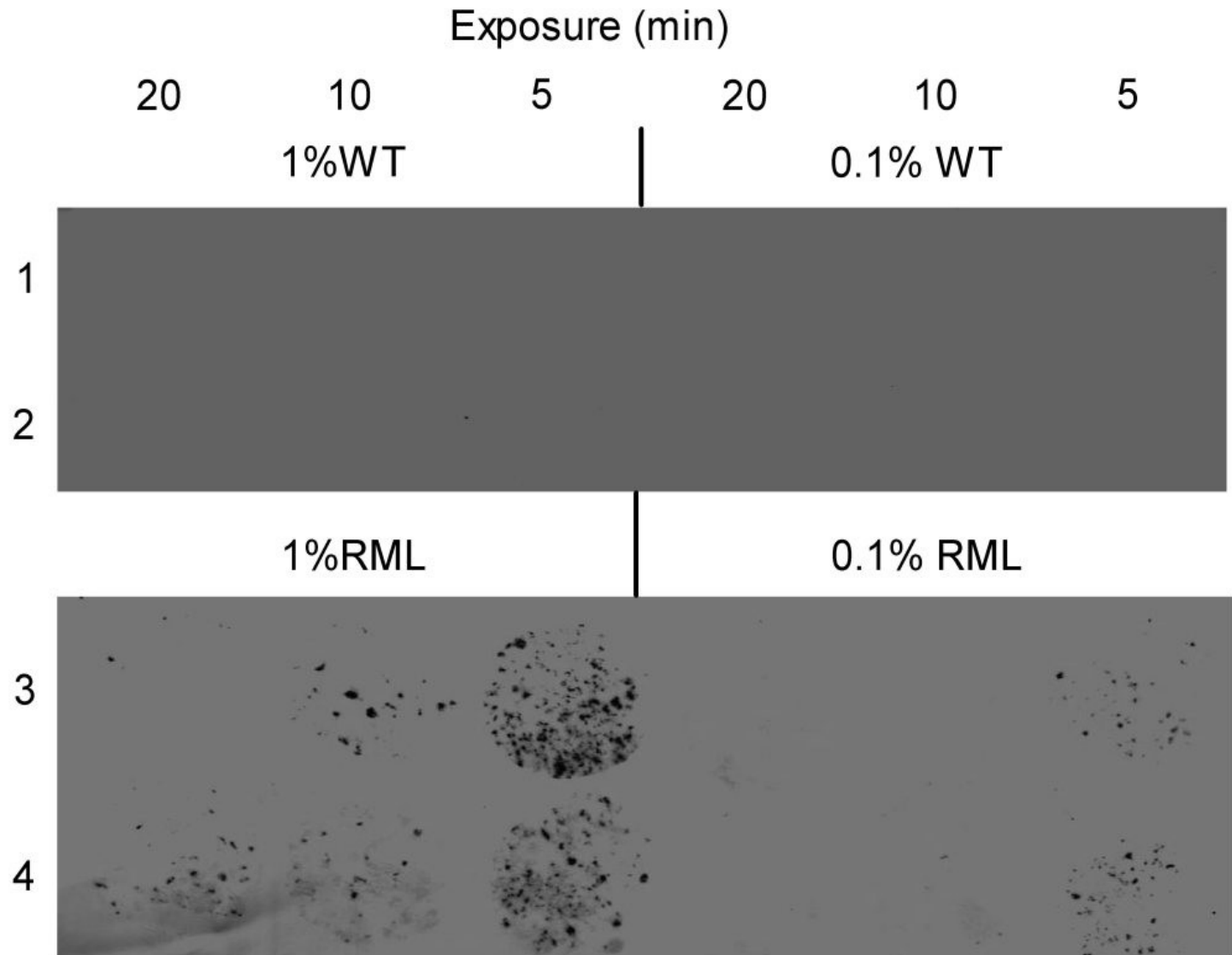




# Použitie $H_2O_2$



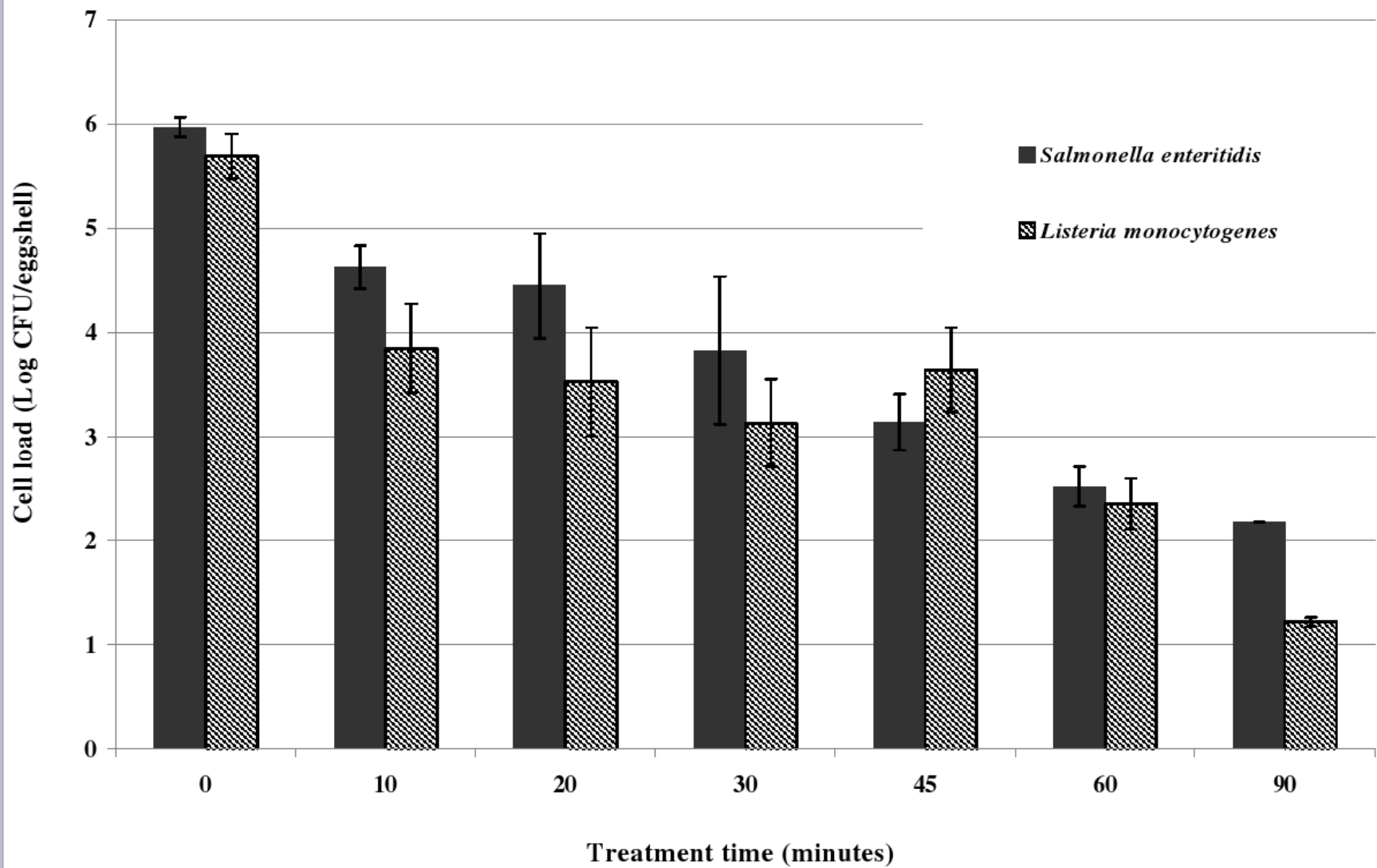
# Inaktivácia priónov



# Bezpečnosť potravín

## Vajcia v Bologni







# Dekontaminácia obalov

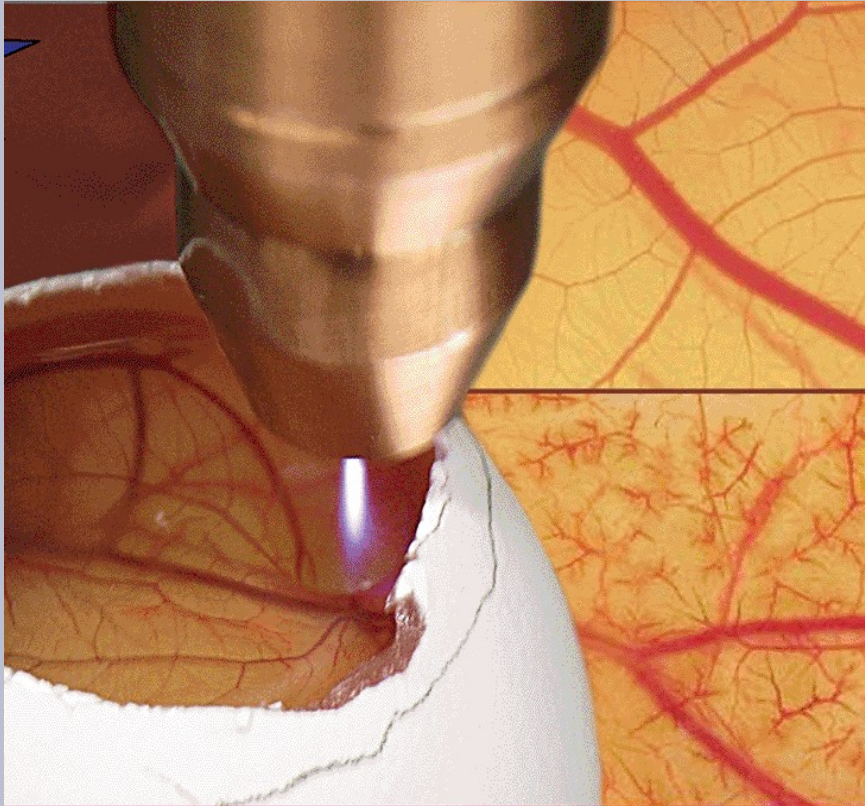


Safety and Quality of  
Packaged Spinach  
Treated  
with a Novel Ozone-  
generation System

Paul A. Klockow and  
Kevin M. Keener

<http://www.purdue.edu/uns/x/2009a/090302KeenerBacteria.html>

# Medicínske aplikácie



Cladudia Bender  
Greifswald

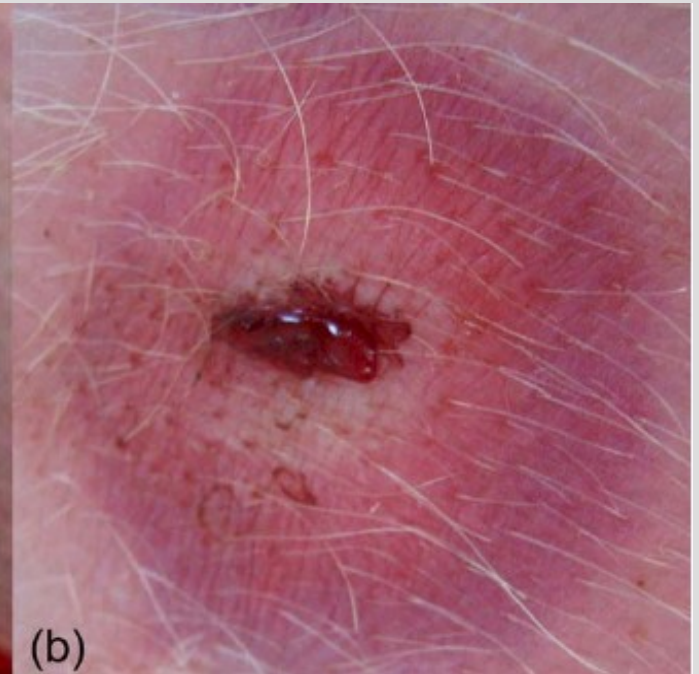


Fig. 1: Plasma treatment of the wound.



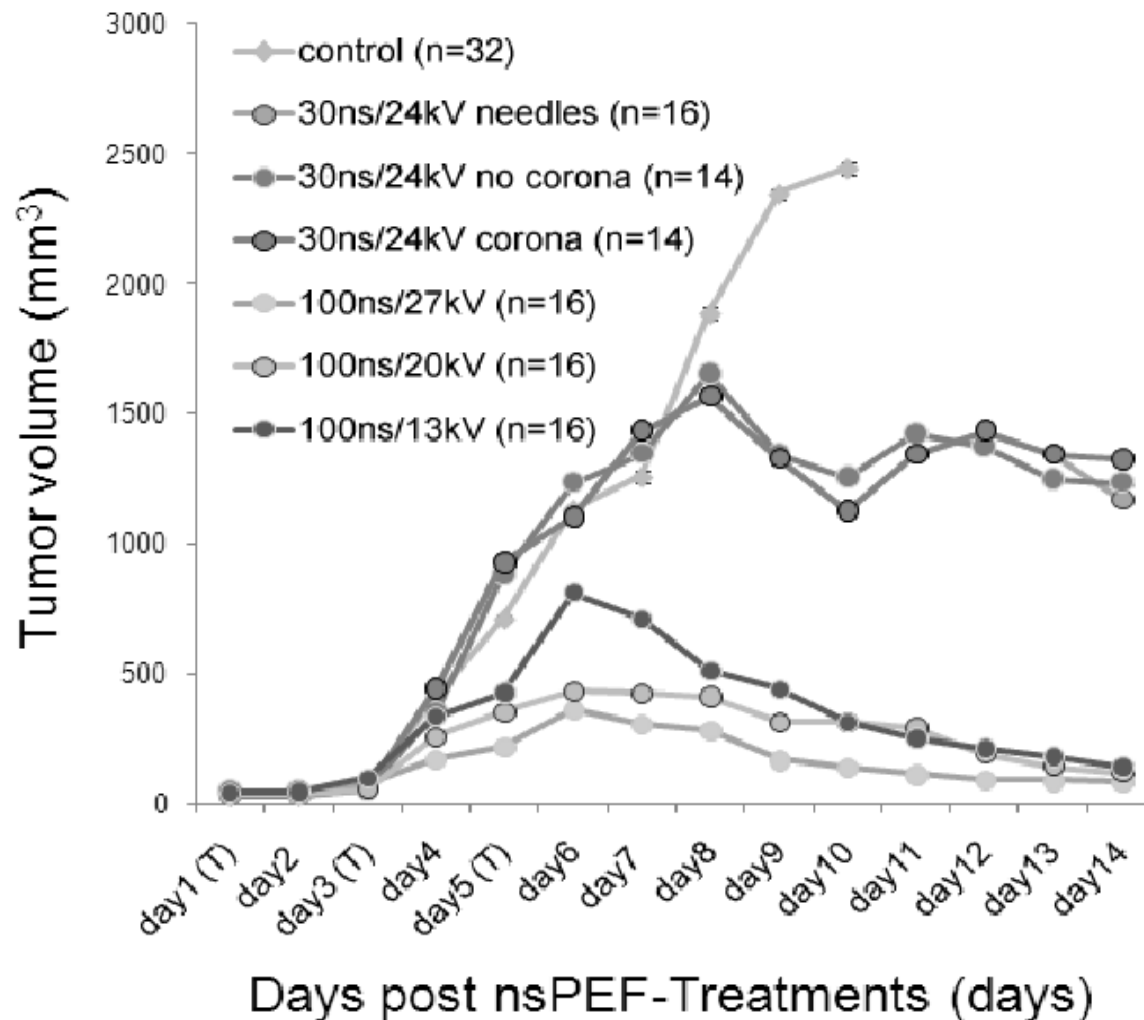


# Koagulácia krvi



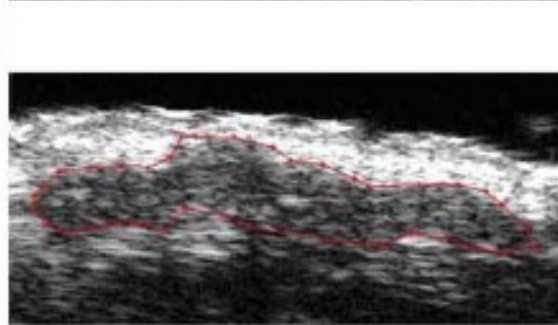
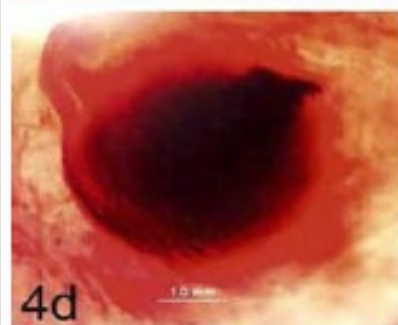
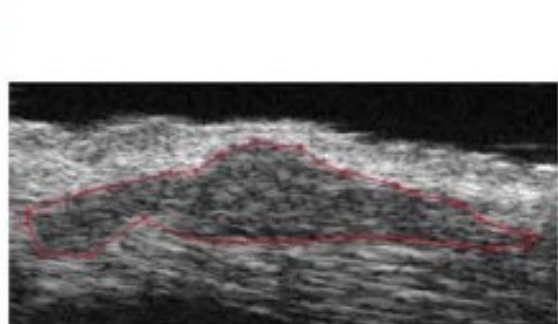
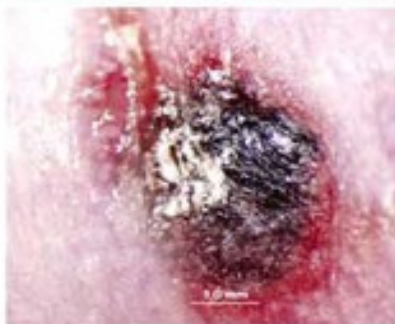
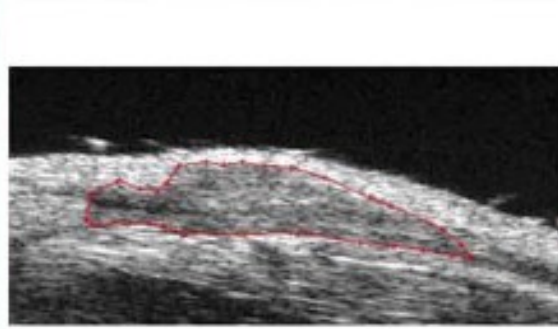
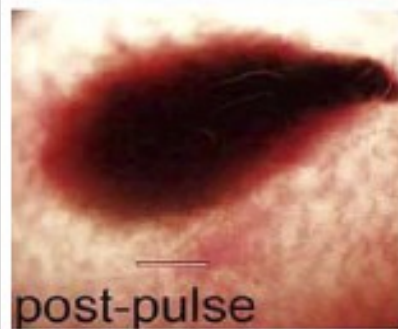
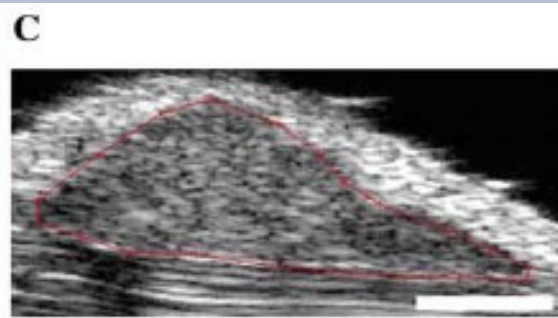
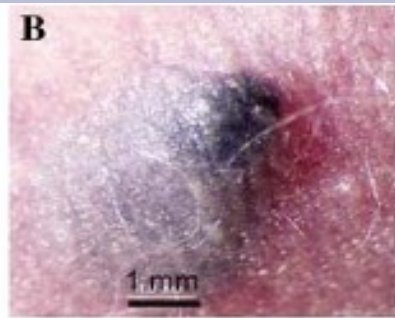
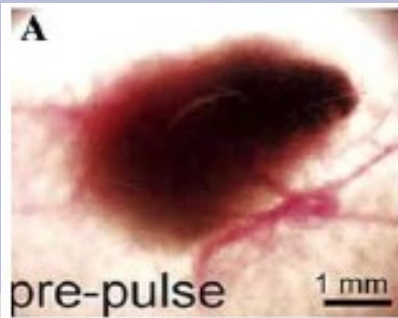
S. P. Kuo - USA

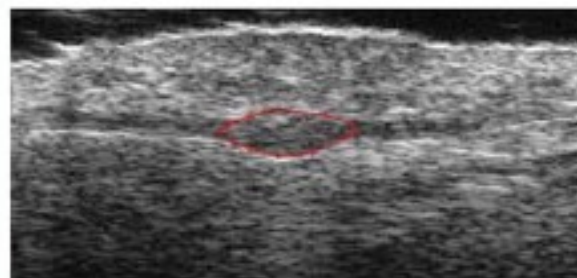
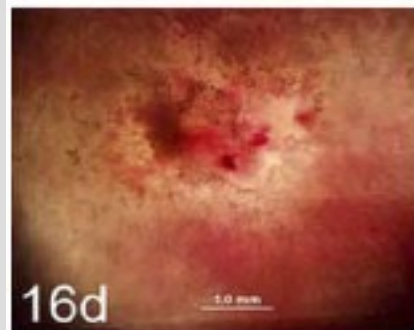
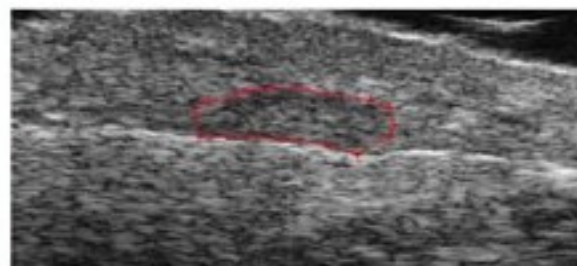
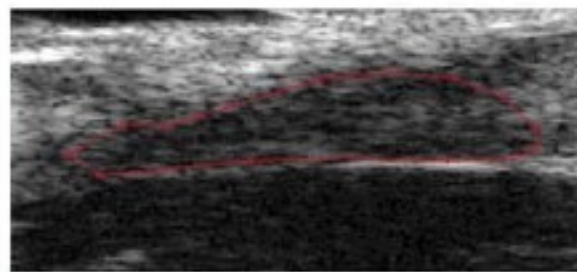
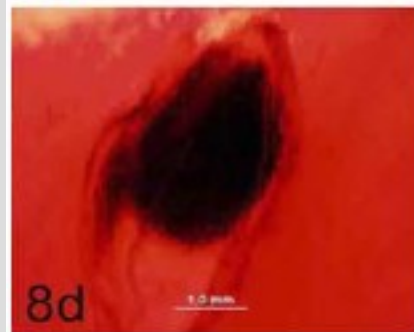
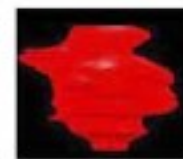
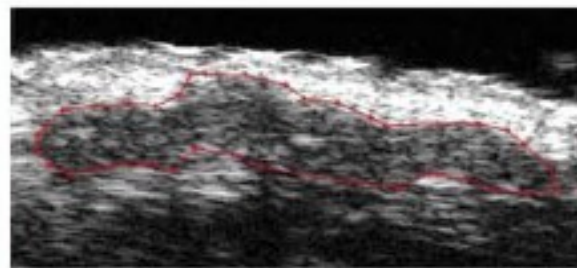
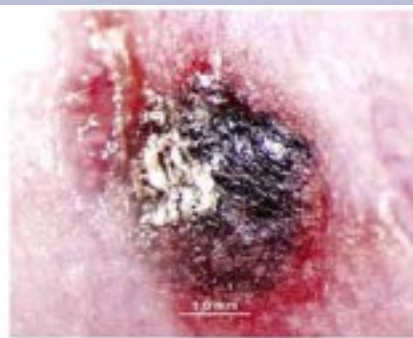
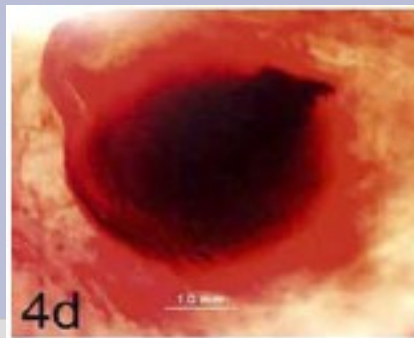
# Apoptóza



Kolb, J.F.; Chen, X.; Zhuang, J.; Ren, W.; Scully, N.; Swanson, R.J.; Beebe, S.J.; Schoenbach, K.H.; , "Tumor treatment with nanosecond pulsed electric fields," Pulsed Power Conference, 2009. PPC '09. IEEE , vol., no., pp.880-885, June 28 2009-July 2 2009



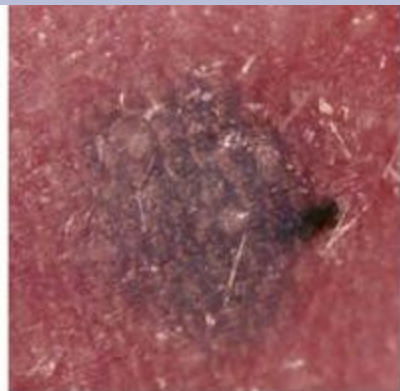
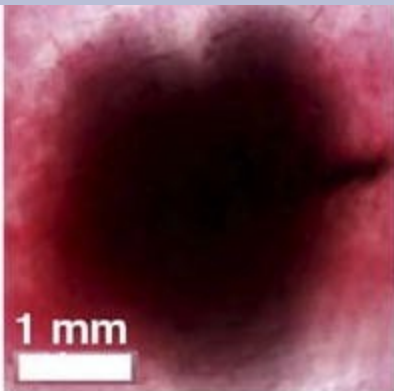






# Apoptóza

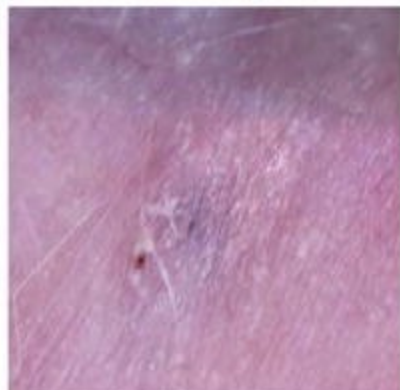
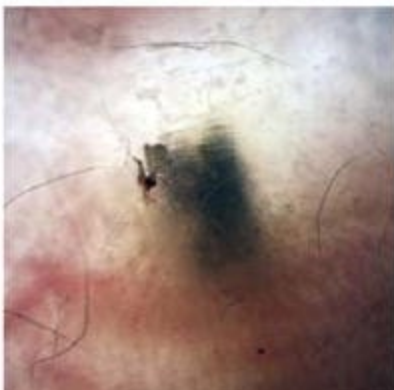
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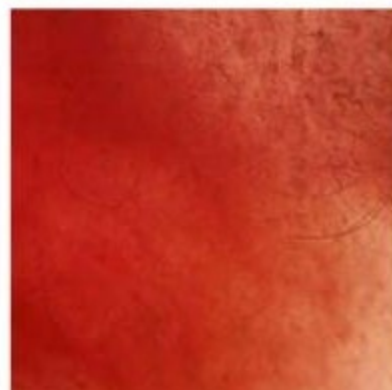
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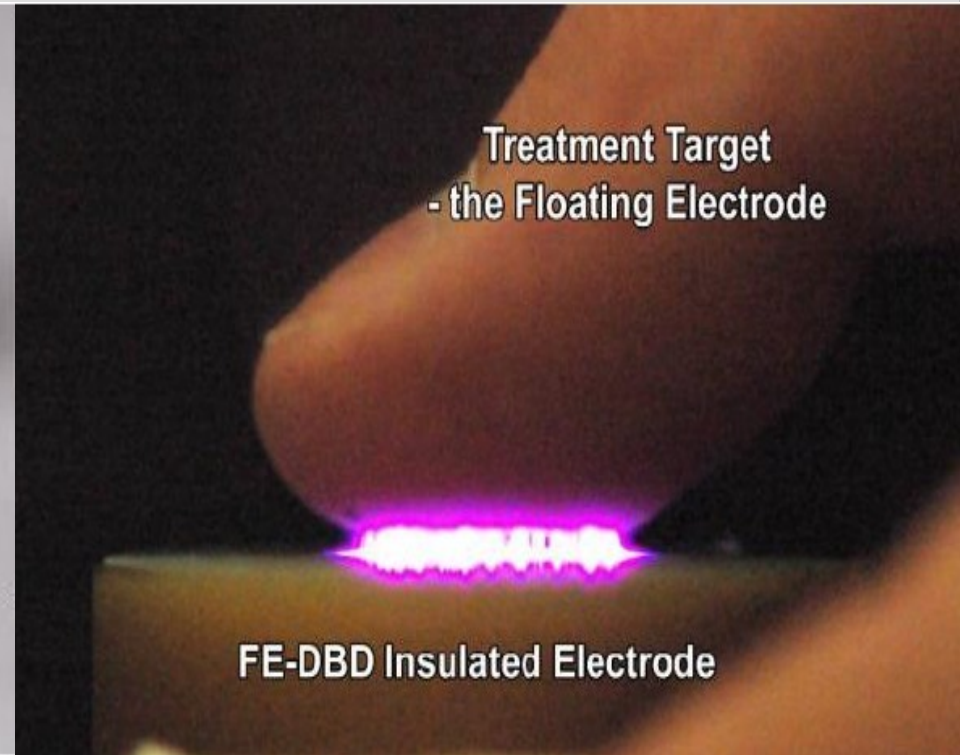
21 d



65 d



# Fridmani

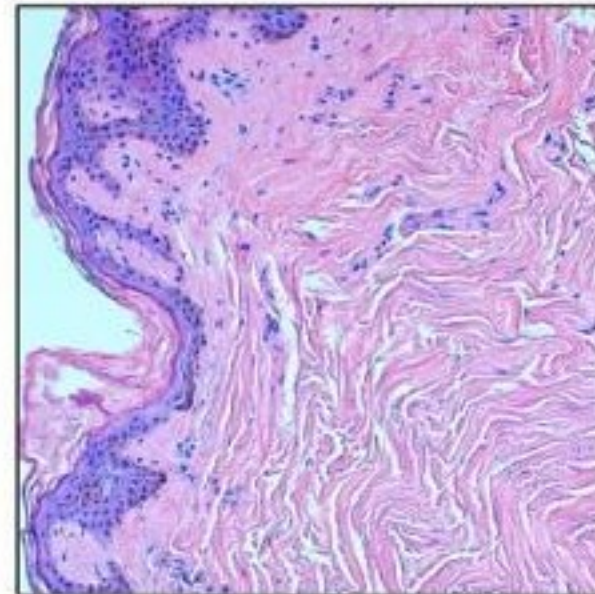
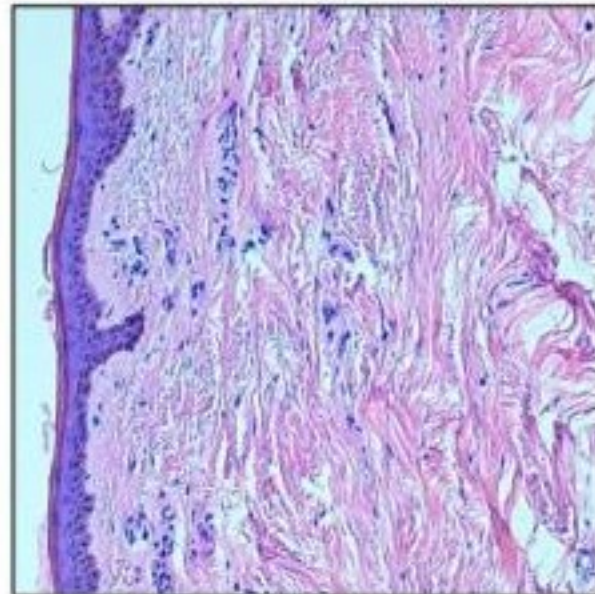
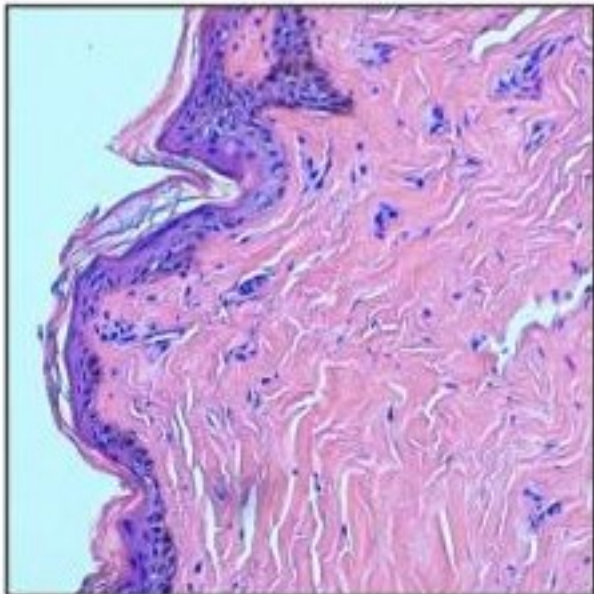
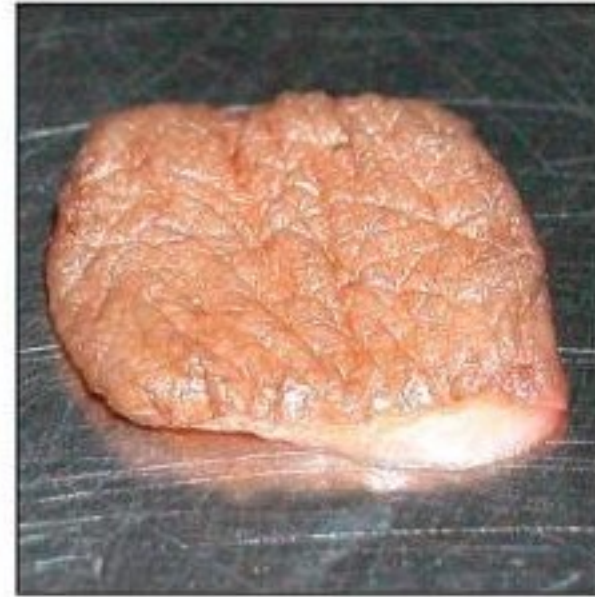


Applied Plasma Medicine by G. Fridman, G. Friedman, A. Gutsol, A.B. Shekhter, V.N. Vasilets, A. Fridman in Plasma Processes and Polymers, **2008**

# Expozícia tkanív







# Koagulácia krvi



Saphenous vein  
is a major blood vessel for a mouse



If left untreated following a cut  
animal will bleed out (control)



15 seconds at 0.8 Watt/cm<sup>2</sup> stops the  
bleeding completely right after treatment





**Before treatment**

**21st day of  
NO-therapy  
(10 seances)**

**After 2 months  
of NO-therapy**





**Before treatment**



**After 4,5 months of NO-therapy  
(3 courses of NO-therapy;  
12 seances per course)**



# Veselé Vianoce

