

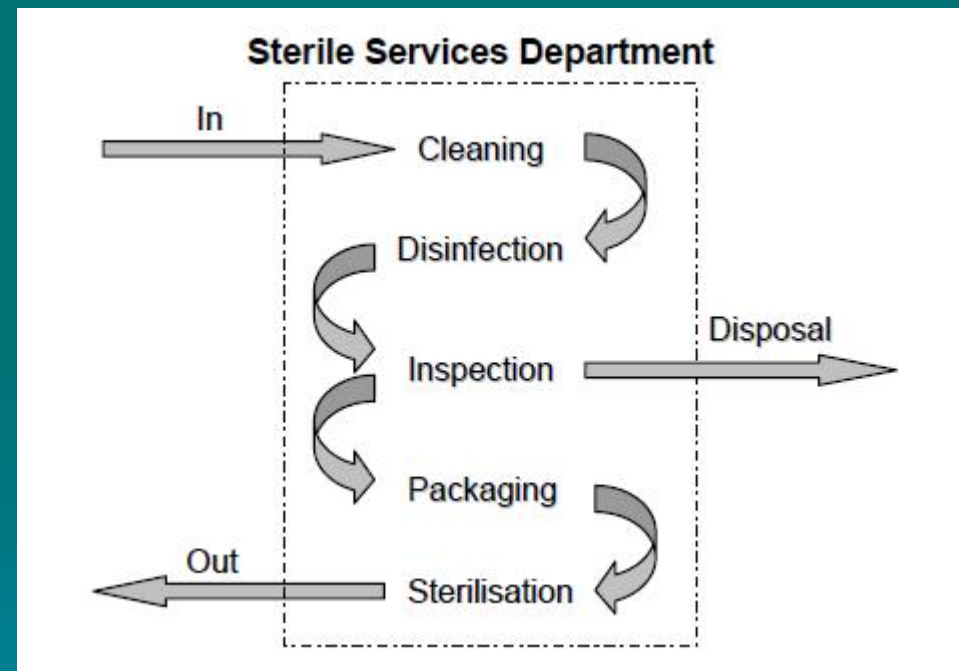
Potential of Cold Atmospheric Plasma as a new method for the decontamination and sterilization of reusable surgical instruments.

14th World Sterilization Congress
8th National Sterilization Disinfection Congress of Turkey

6th-9th November 2013

Rodolphe Hervé PhD, MSc

Standard reprocessing



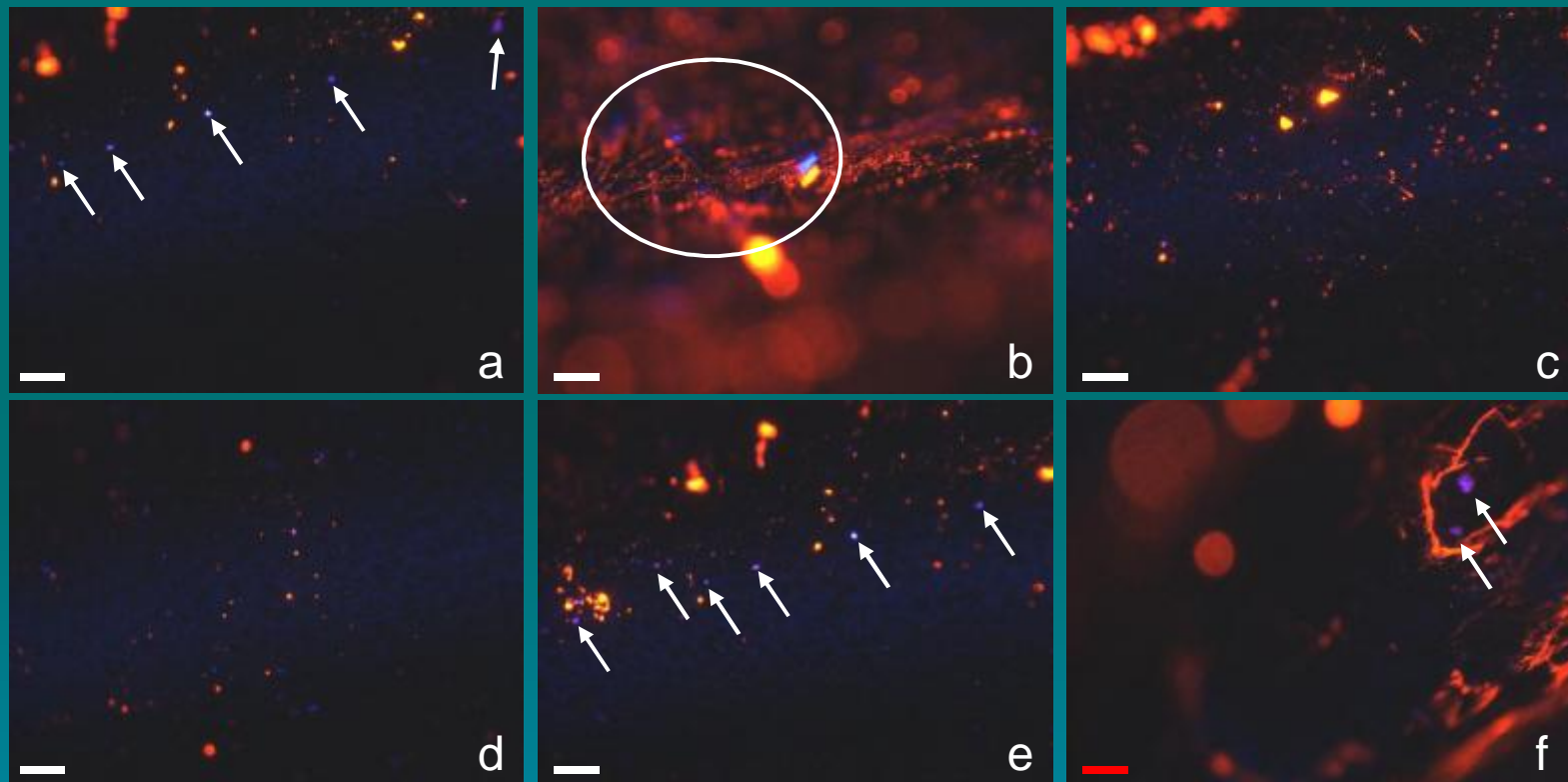
The five main functions performed in a hospital sterile service department

Decontamination and sterilization



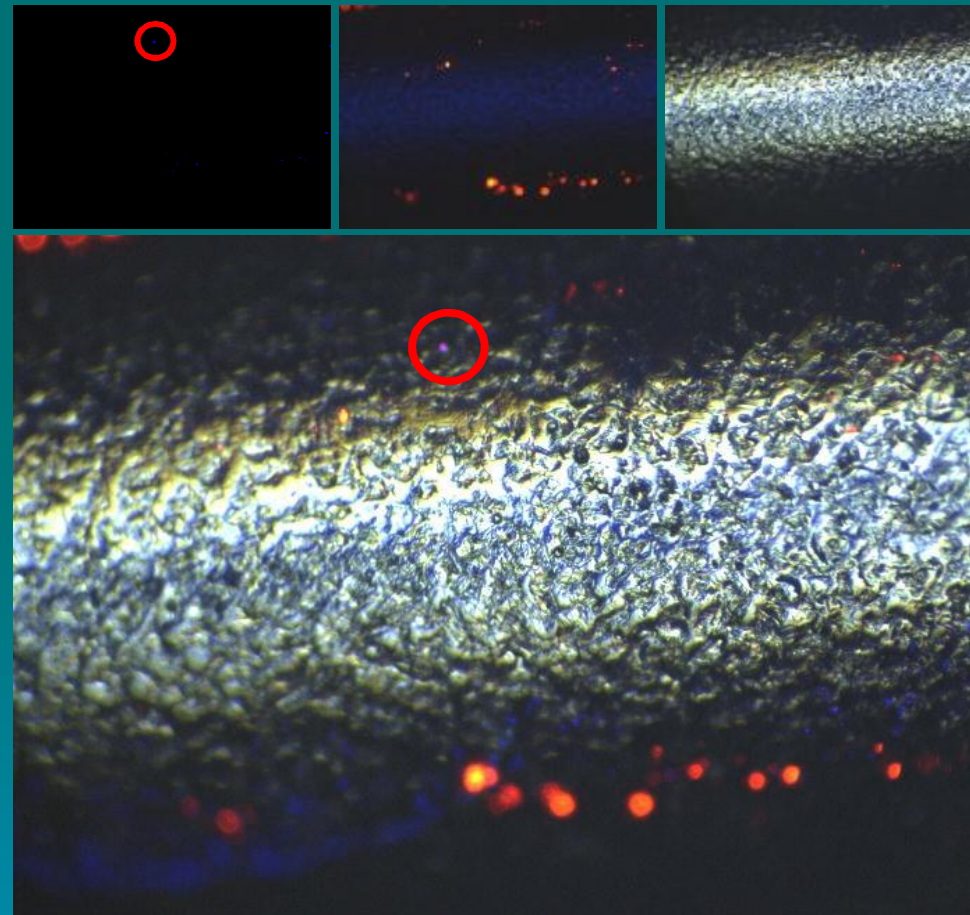
Assessment of instruments cleanliness

Standard reprocessing: neurosurgery instruments



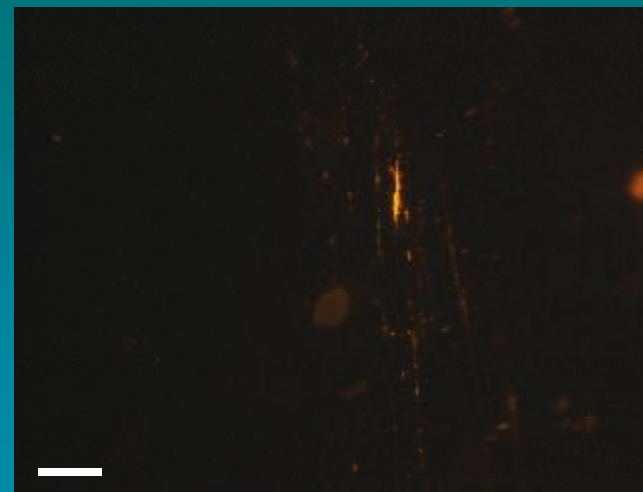
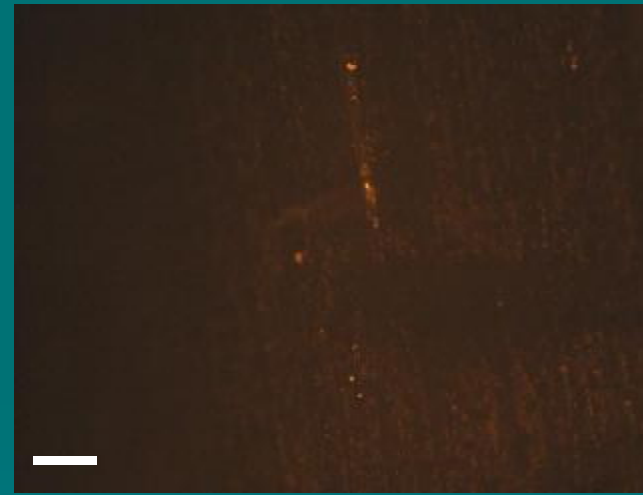
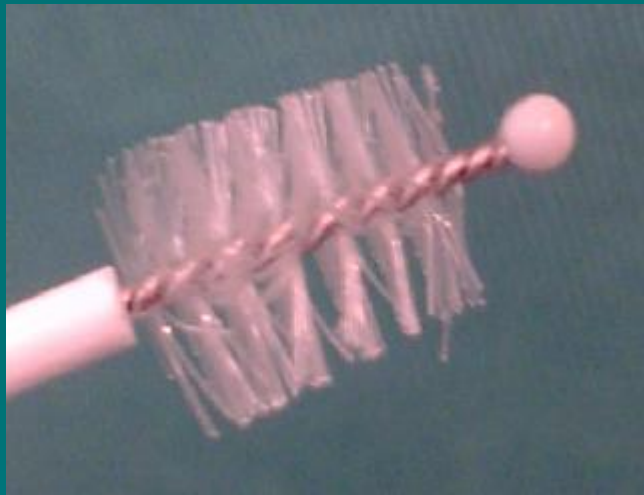
Thioflavin T (bright blue) and SYPRO Ruby (amber) dual staining observed on (a-e) a suction canulae and (f) diathermy forceps from a neurosurgery set that were fully reprocessed through a sterile service department. White bars are 100 μm , red bar is 10 μm .

Standard reprocessing: neurosurgery instruments

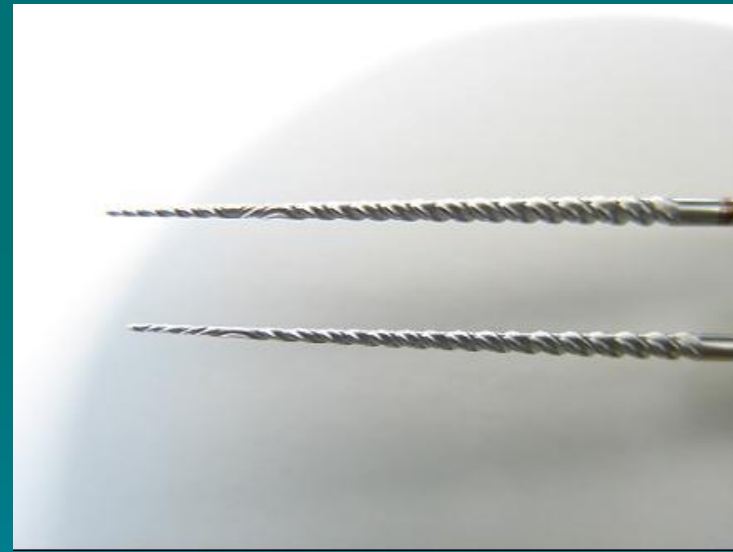


Proteinaceous (total and amyloid) contamination on a suction cannulae isolated from a craniotomy set.

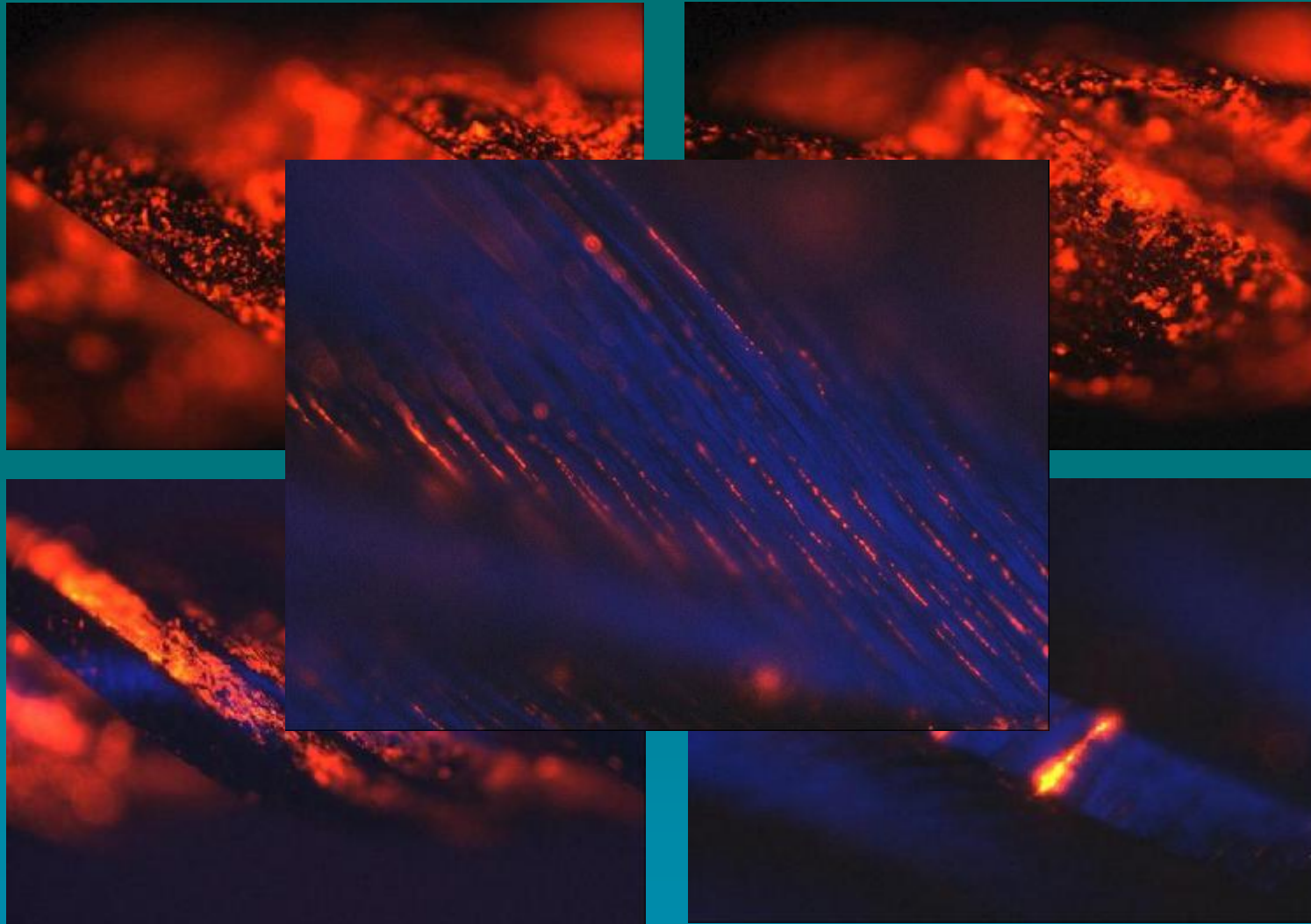
Standard reprocessing: flexible luminal endoscopes



Standard reprocessing: endodontic files

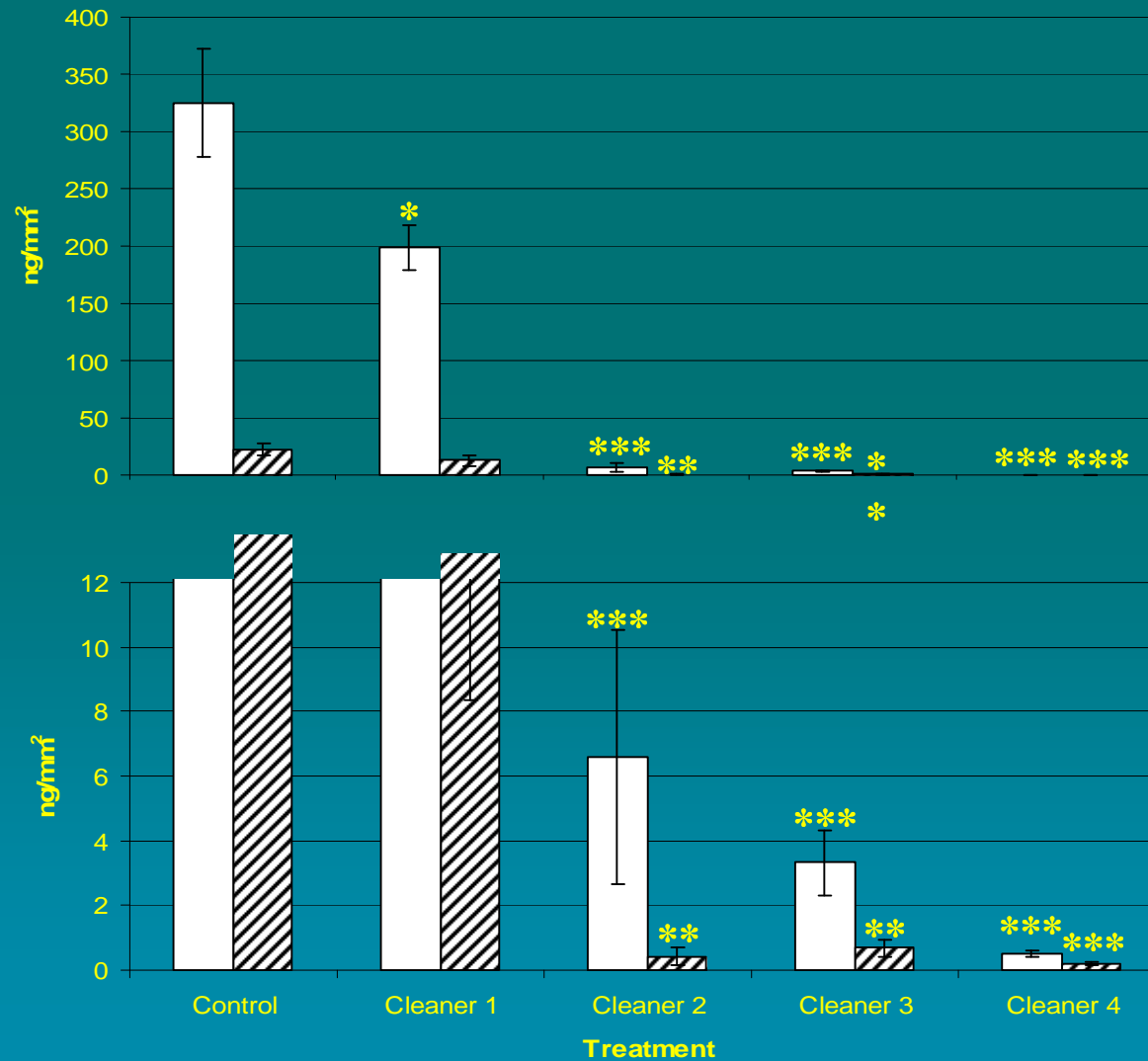


Standard reprocessing: endodontic files



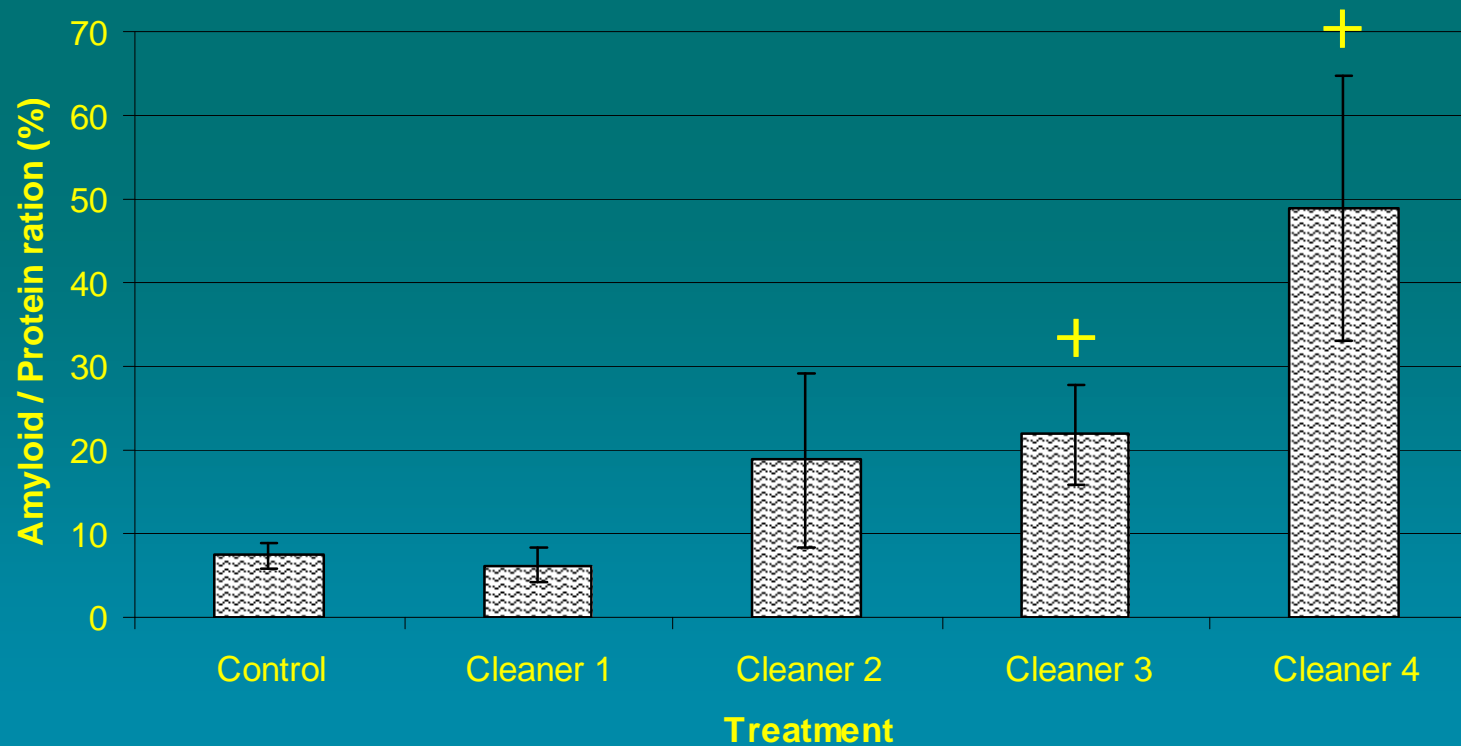
Cleaning limitations

Protein removal action of various cleaners



Cleaning limitations

Remaining contamination on surfaces
(proportion of hydrophobic amyloid-rich proteins)



How can standard cleaning fail ?

Mechanism

Physical disruption
(detergent, sonication,
brushing, flushing)

Enzymatic degradation

Chemical modification
(pH > 12)

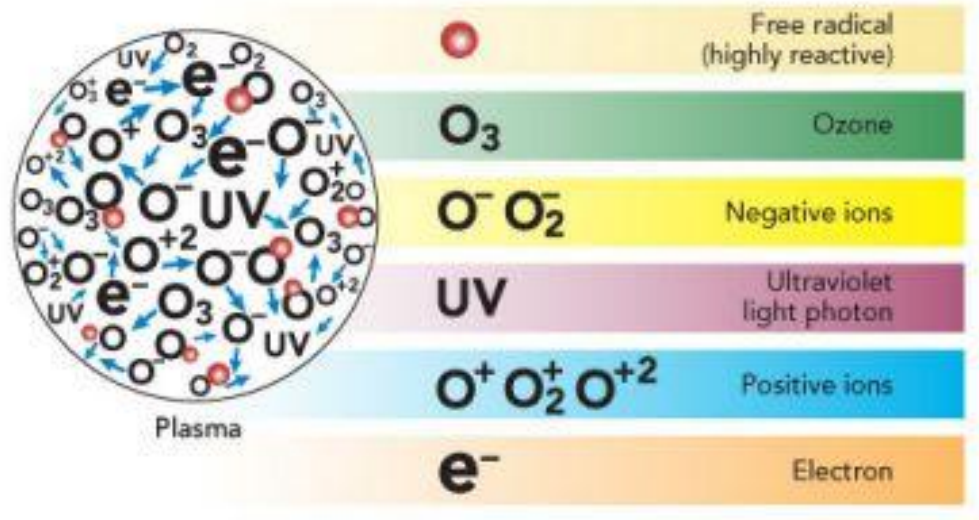
Potential caveats

Displacement and/or
spreading

Shelf life; control of
parameters

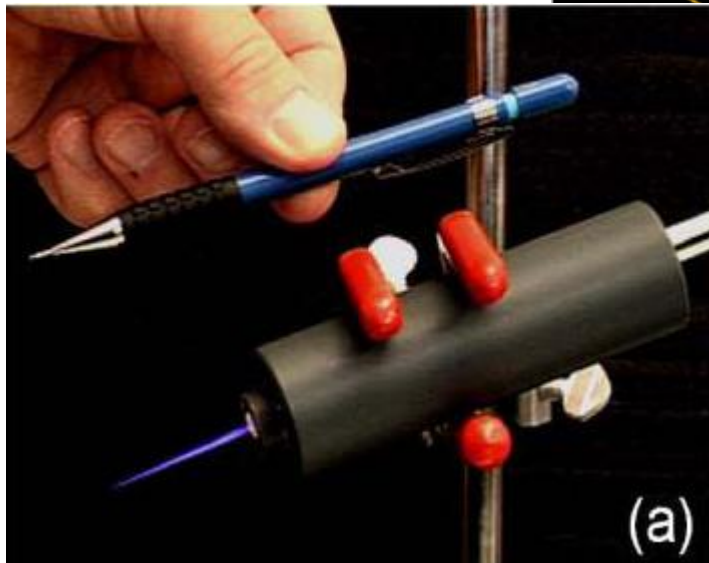
Damage to instruments;
control of parameters
and efficacy

What is gas plasma?



Benefits

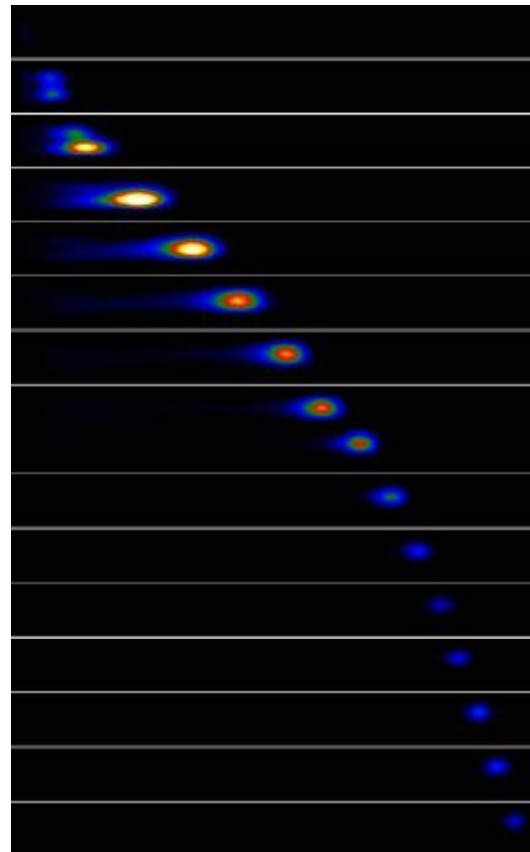
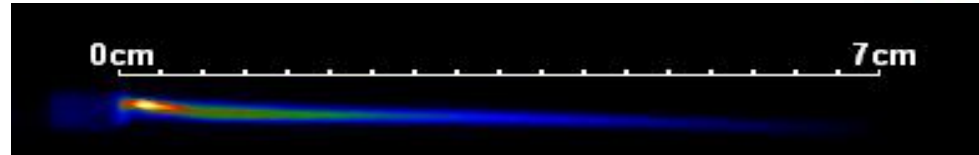
- Energetic electrons \rightarrow chemical dissociation @ low gas temperature
- On-site production of reactive, short-living species e.g. $O_2^{\bullet-}$; O ; 1O_2 ; NO ... OH^{\bullet} and H_2O_2 \rightarrow known to act on protein, lipid and DNA
- **Oxidants:** OH^{\bullet} , $O_2^{\bullet-}$; O ; 1O_2 , H_2O_2



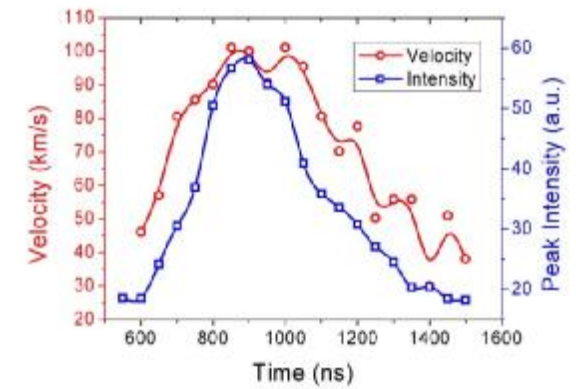
Light
Photon

Non-equilibrium Chemistry

what is gas plasma? | Shooting Plasma

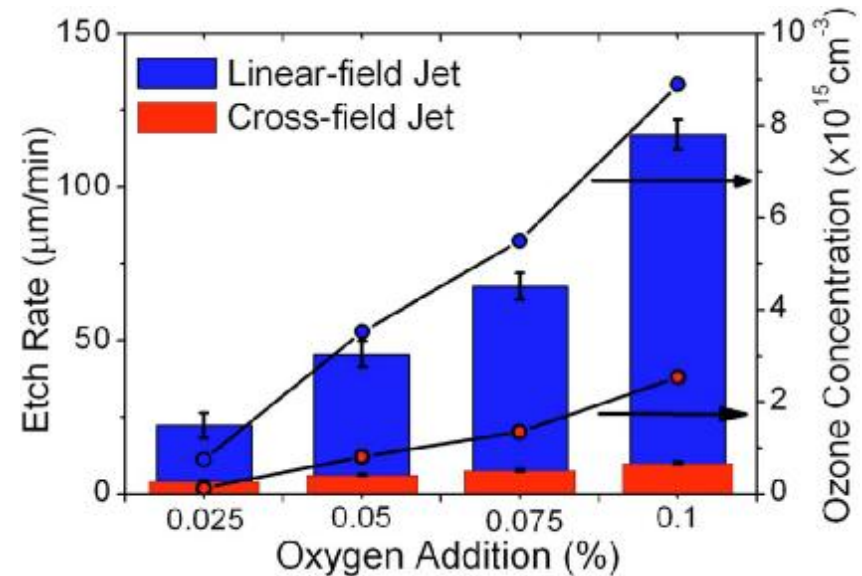
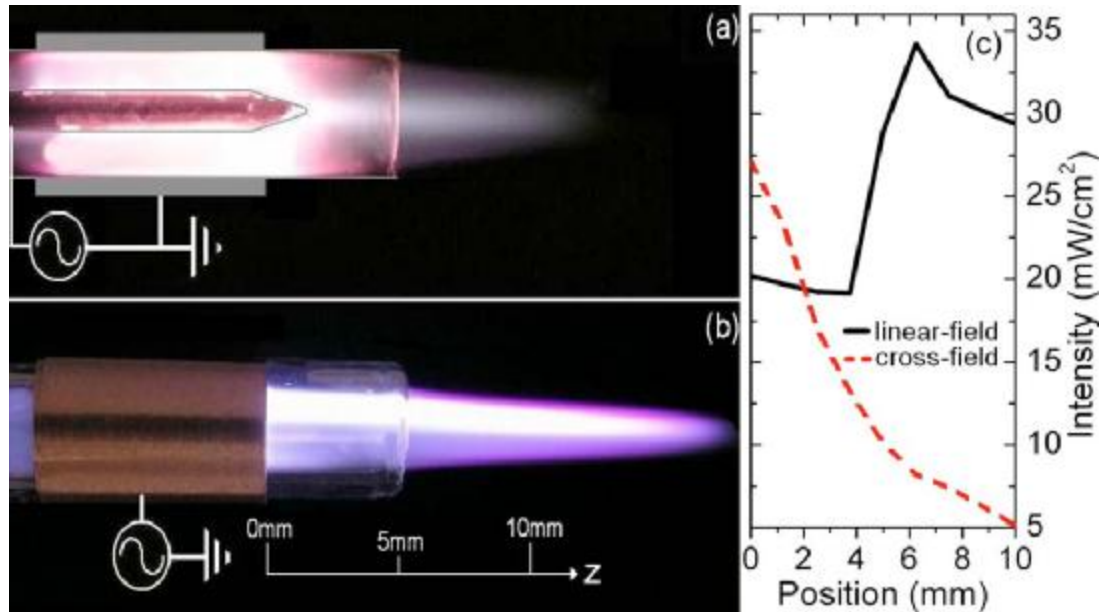


Exposure: **1 ns**
Interval: **100 ns**



Nanosecond imaging

CAP endo-decon | Electron Bombardment



Walsh JL and Kong MG (2008) *Appl. Phys. Lett.* 94: 021501;

Testing of first CAP prototype



CAP parameters during initial tests

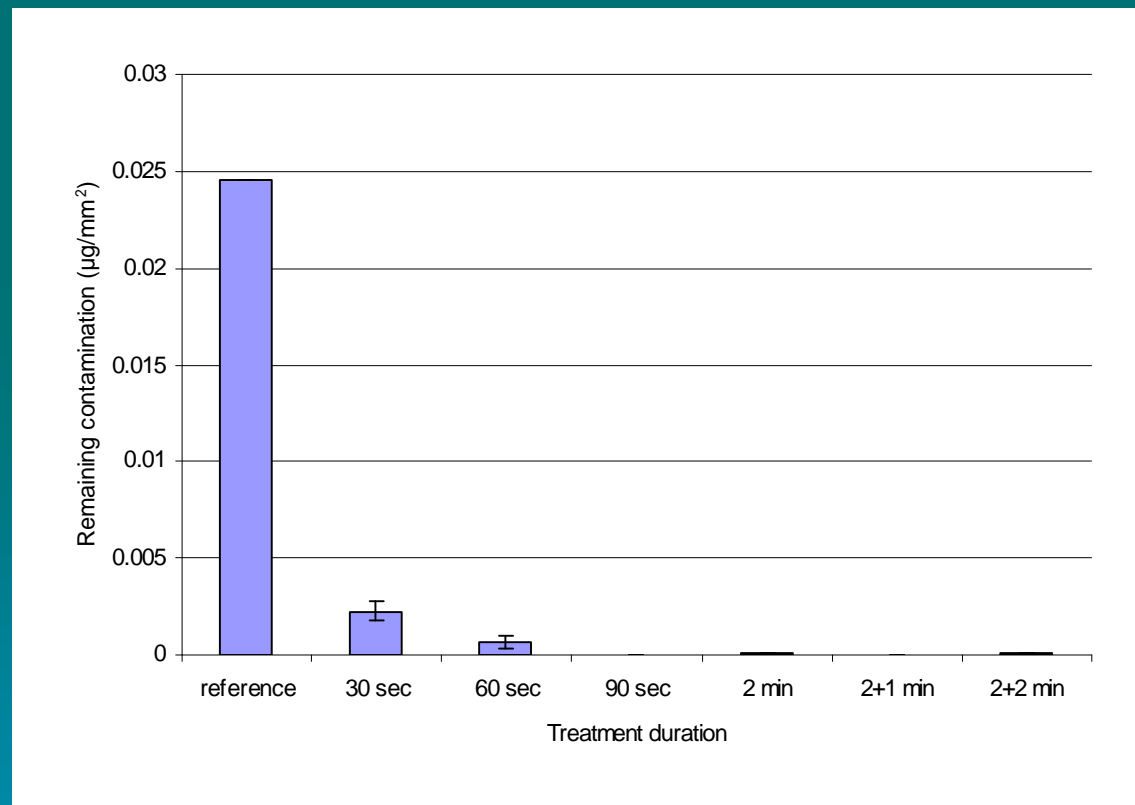
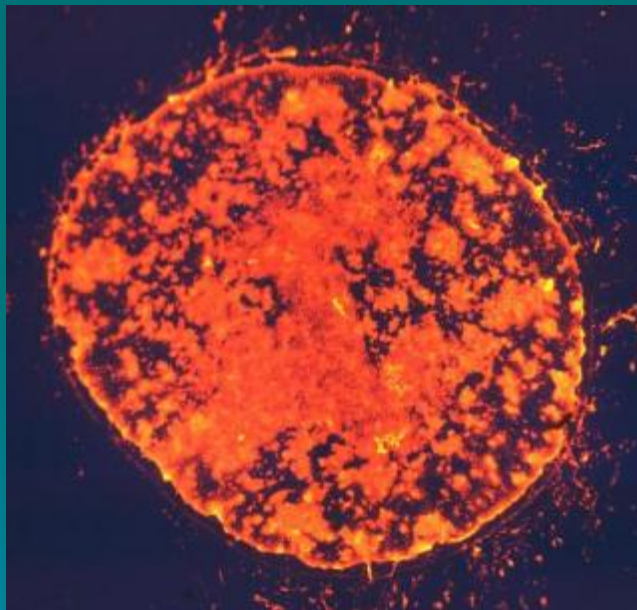
High purity helium/oxygen mix

5 L/min and 100 ml/min respectively

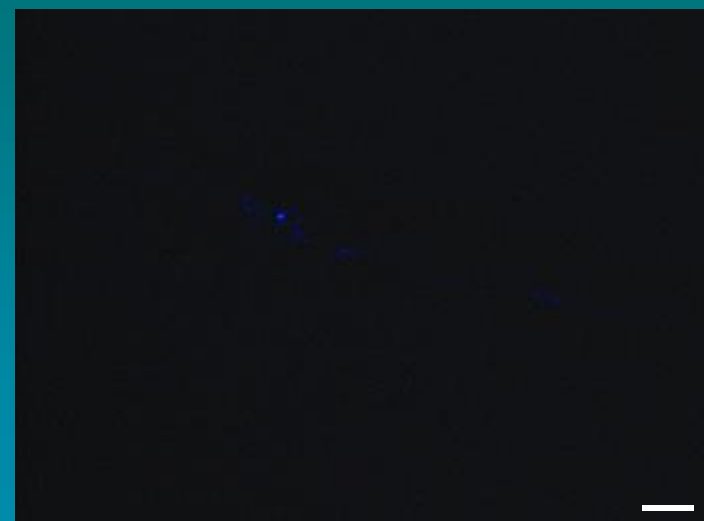
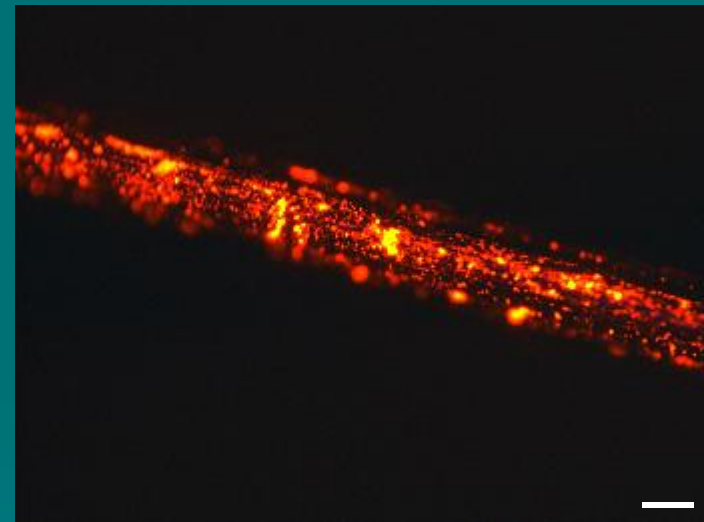
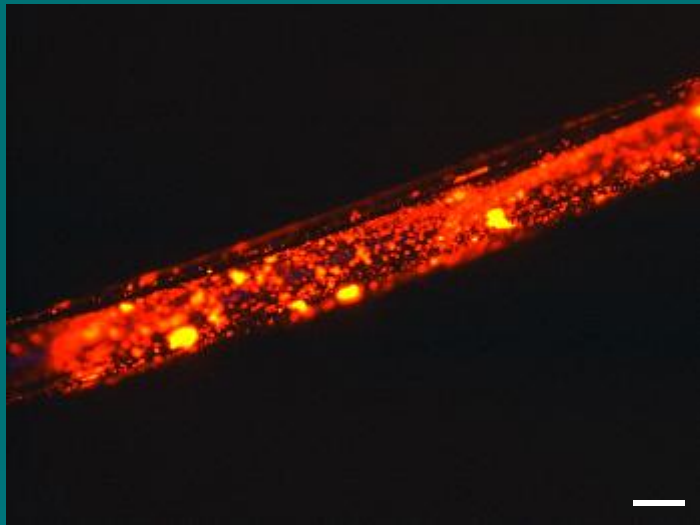
Target surface set within 1.5 cm

Up to 2 min application

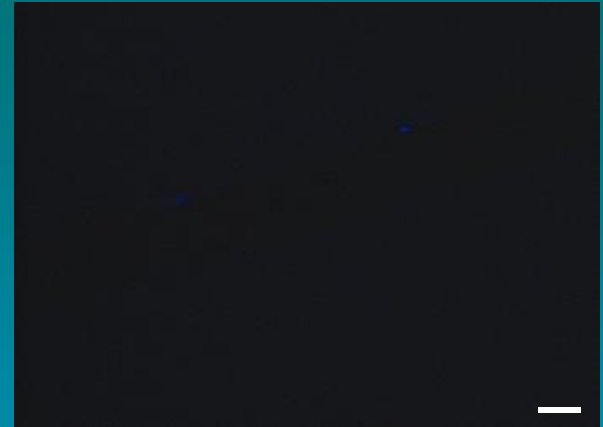
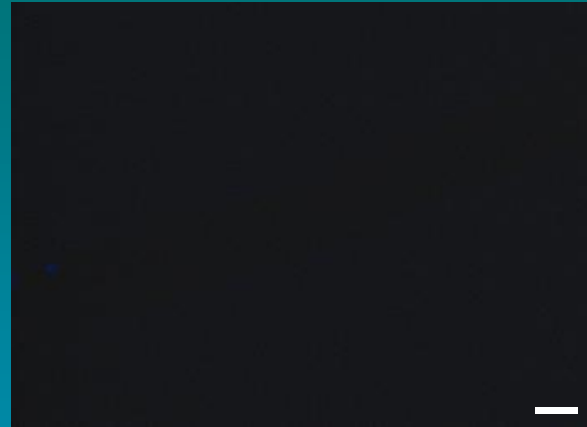
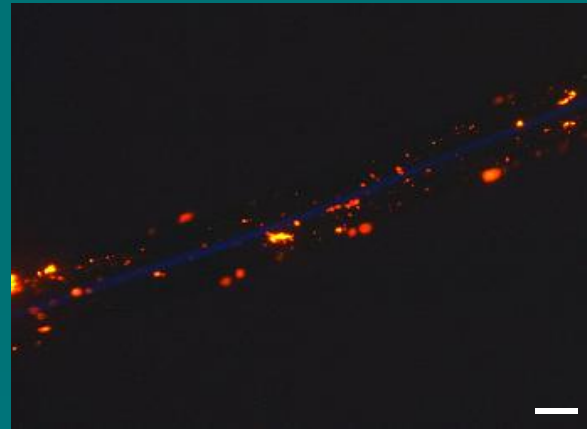
Testing of first CAP prototype



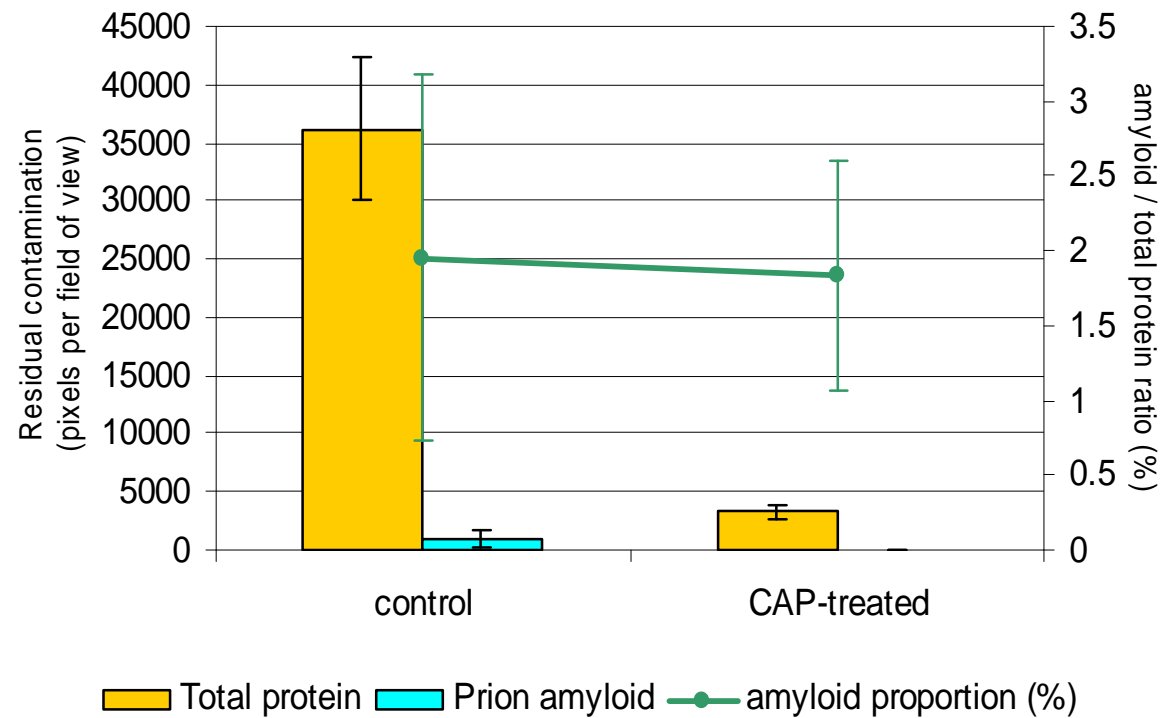
Spiked implant wires before CAP treatment



Spiked implant wires after partial CAP treatment

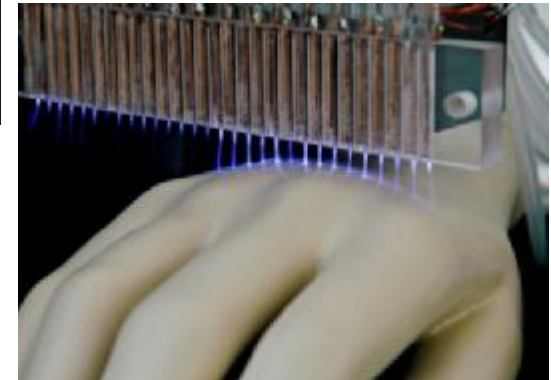
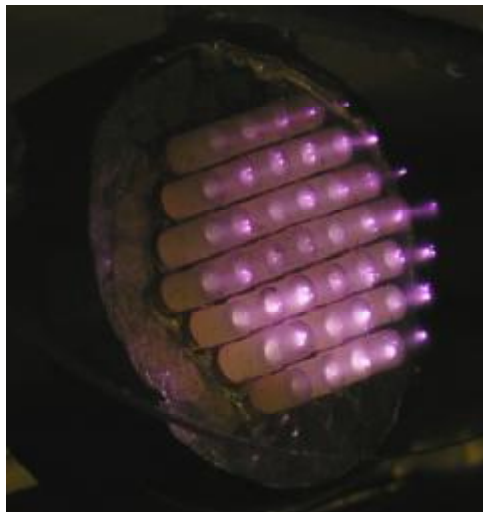
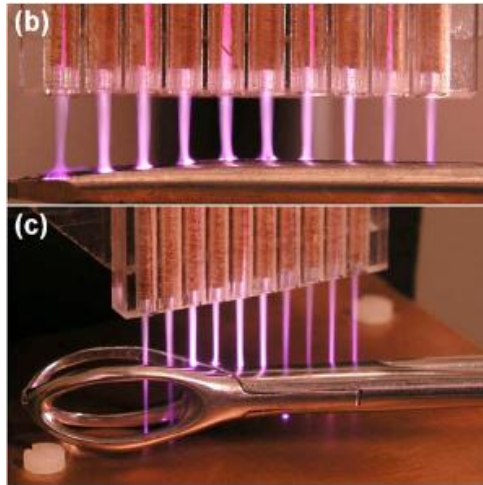


CAP appears equally effective against amyloid proteins



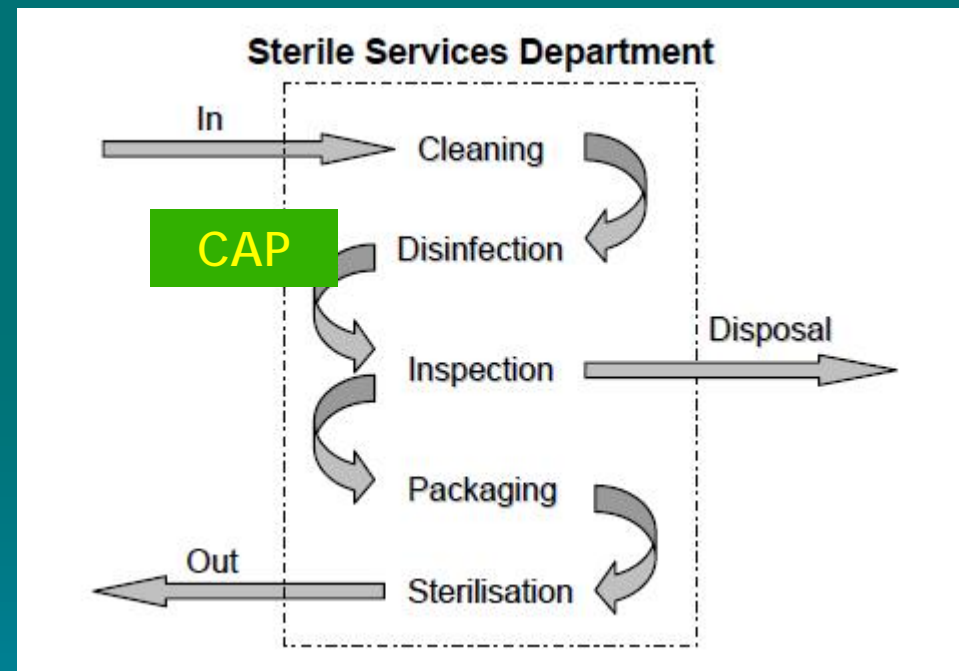
CAP endoDecon | Versatility and Uniformity Control

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Southampton

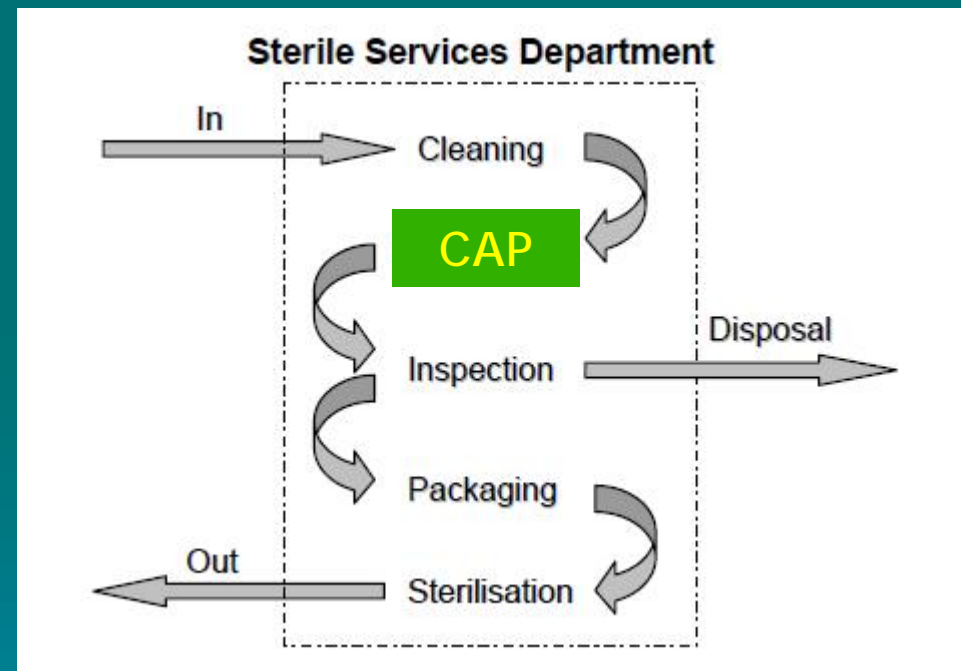


Cao Z et al (2009) *Appl. Phys. Lett.* 94: 021501; Nie Q et al (2009) *New J. Phys.* 11: 115015;
Kong MG (2011) *J. Phys. D: Appl. Phys.* 44(17): 174018; Walsh JL et al (2008) *IEEE Trans. Plasma Sci.* 36(4): 1314.

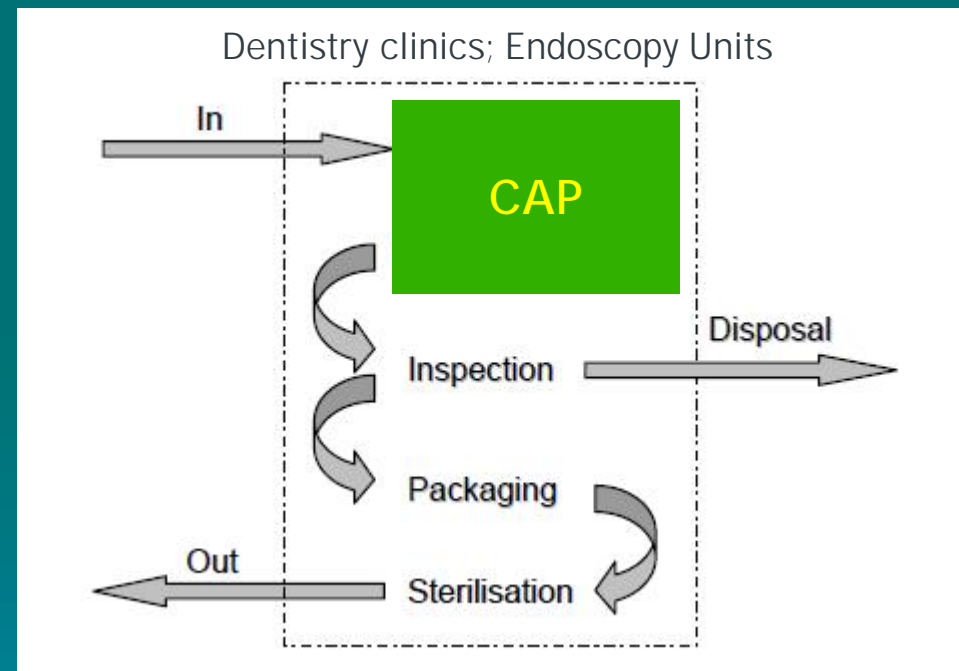
The place of CAP in standard reprocessing



The place of CAP in standard reprocessing



The place of CAP in standard reprocessing



Ar-O₂-H₂O Plasmas

- up to 1,000 chemical reactions
- threshold dose of each protein-inactivating plasma agent is unknown
 - complication with synergy
 - plasma diagnostics is complex and not always accessible
 - plasma diagnostics in liquid phase – very under-studied field
 - if achieved, a **knowledge-based inaction** – indirect **inactivation marker**
- ... empirical strategy – **unreliable** for ensuring efficacy and for system scaling

Agents	Plasma Characterisation
O* ; OH* etc	Excited species – Optical emission spectroscopy(OES)
O, H ₂ O-clusters	Ground state – OES not good – MBMS
OH, H ₂ O ₂ etc in H ₂ O	Electron spin resonance (ESR) spectroscopy
UV	Absolute OES
Ozone	Spatial resolved – UV absorption spectroscopy (UVAS)
Electron density	Probes not applicable – current density
Electron energy	Boltzmann plot
All	Plasma modelling

... additional studies, such as OH scavengers

CAP optimisation

EDIC/EF for rapid and very sensitive quantification of residual proteins and microorganisms.

Refined prion infectivity assays for human strains under development.

Mechanisation and scaling up of the process.

Adaptation into SSDs.

Conclusions

Proteinaceous microcontamination (potentially including PrP^{Sc} in affected countries) is a common problem in clinical settings.

Current standard decontamination procedures suffer from inherent physicochemical limitations.

CAP offers a radically different decontamination mechanism capable of targeting individual atoms, without the problems associated with liquid solutions.

Further development required to adapt the technology to different end users/instruments.

Acknowledgements

SSDs (England)

CEA (France)

The Pirbright Institute

NCJDSU (Edinburgh)

Public Health England

English Department of Health

Fondation Alliance BioSecure

A photograph of a sunset over a body of water. The sun is a bright orange semi-circle on the horizon. The sky is a gradient of orange and brown. The water is dark with a yellowish glow at the bottom. The text "Thank you!" is written in white, sans-serif font across the top half of the image.

Thank you!

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