

# Plasma Medicine in Cardiac Surgery – Treatment of the Beginning Driveline Infection with Cold Atmospheric Plasma (CAP)



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CENTER MECKLENBURG-VORPOMMERN, GERMANY***

***LEIBNIZ INSTITUTE FOR PLASMA SCIENCE AND  
TECHNOLOGY (INP GREIFSWALD), GREIFSWALD,  
GERMANY***

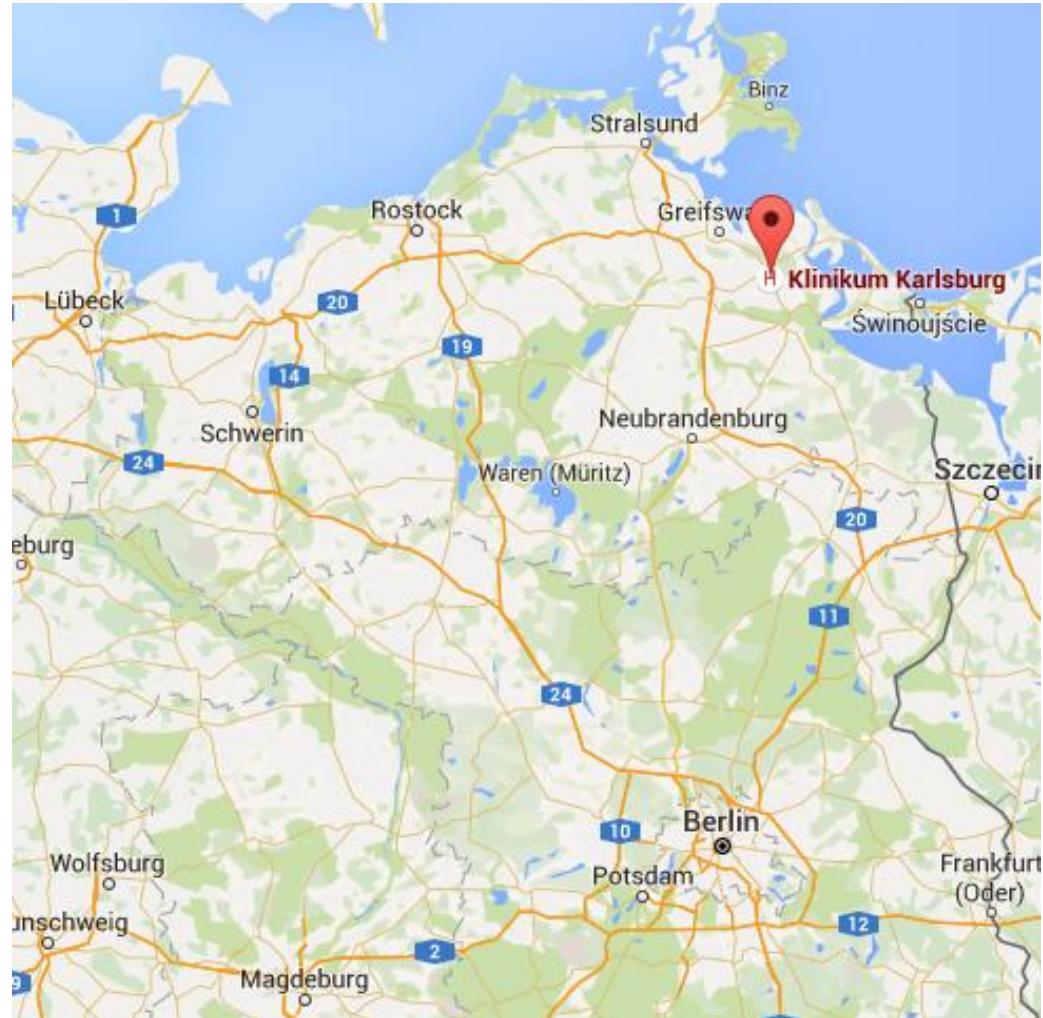
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<input type="checkbox"/>	X	<input type="checkbox"/>	X
B	B	B	B
... from any institution	... from any institution	... for any institution	... <u>not related</u> to presentation
<b>YES</b>	<b>NO</b>	<b>YES</b>	<b>NO</b>
<input type="checkbox"/>	X	X	<input type="checkbox"/>

**SCORE:** 0 1 0 0

I have no relevant financial relationships within the products or services described, reviewed, evaluated or compared in this presentation.



Klinikum Karlsburg –  
Heart and Diabetes Center  
Mecklenburg-Vorpommern



# Clinical Management of Outpatients with HVAD: The KARLA-Project



## Schwester Karla mobile

LVAD-coordinator and patient with the „Schwester Karla“ - mobile

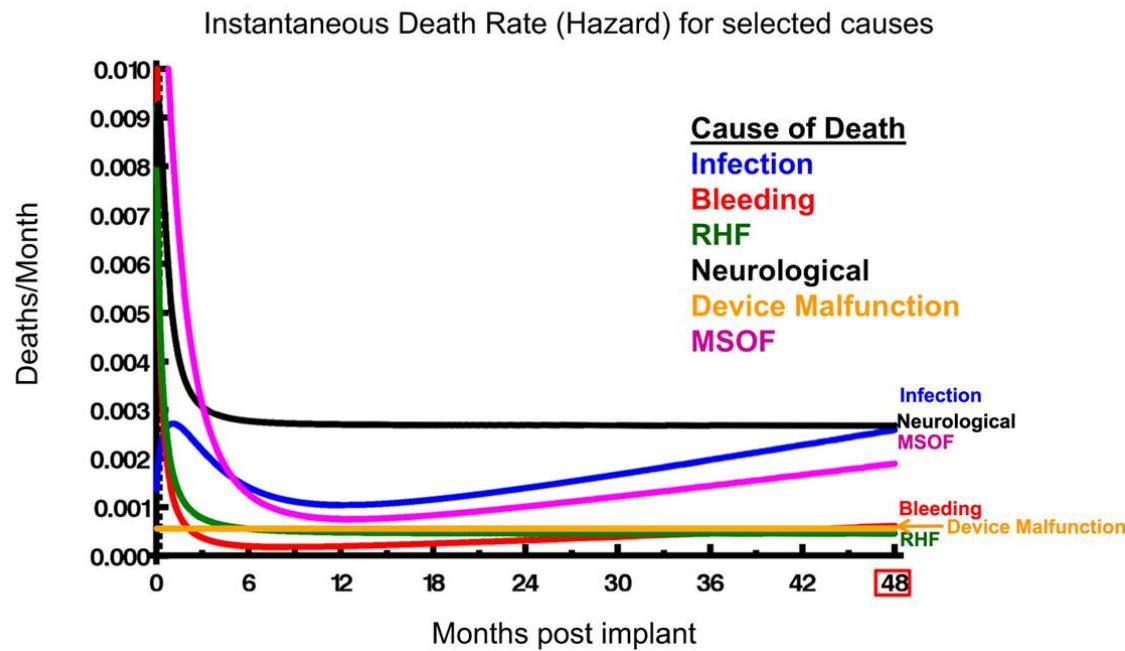
5 perfusionist organizing home visit`s every 2-3 weeks  
Equipment:

HeartWare-monitor,  
hemodynamometer,  
Siemens-xprecia,  
dressing equipment,  
camera, cellphone  
kinPen Med pocket

## Earlier Detection:

- Beginning driveline infections
- Problems with the INR – self management
- Signs of right heart failure and decompensation
- Wounds or infections as a trigger of bacteriemia
- Hemolysis
- Cerebral deficits as signs of embolisation
- Technical problems of the equipment
- Depressive episodes

**Intermacs Continuous Flow LVAD/BiVAD Implants: 2008 – 2013, n = 9372**



# Plasma: the 4<sup>th</sup> state of matter

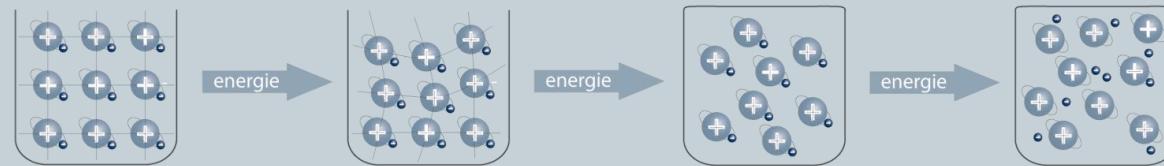


solid

liquid

gas

plasma



More than 99% of all known matter is in plasma state!

# Plasma, biology and medicine?

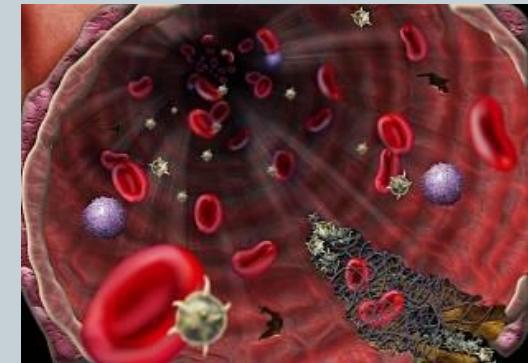
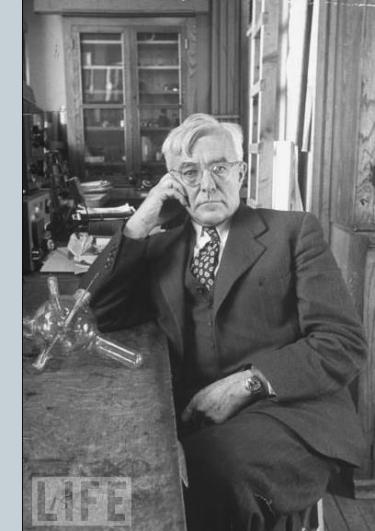


First use of the term „plasma“: Langmuir (1928)

Irving Langmuir's coining of „plasma“ was described by H.M. Mott-Smith:

*„... the discharge acted as a sort of substratum carrying particles of special kinds [...] This reminds him of the way blood plasma carries around red and white corpuscles and germs. So he proposed to call our ‚uniform discharge‘ a ‚plasma‘. Of course we all agreed.“*

Irving Langmuir  
(1881–1957)  
at General Electric  
Laboratory (1948)



# Plasma for biomedical applications

## Biomedical Applications

Surface  
Modification



Therapeutic  
Applications



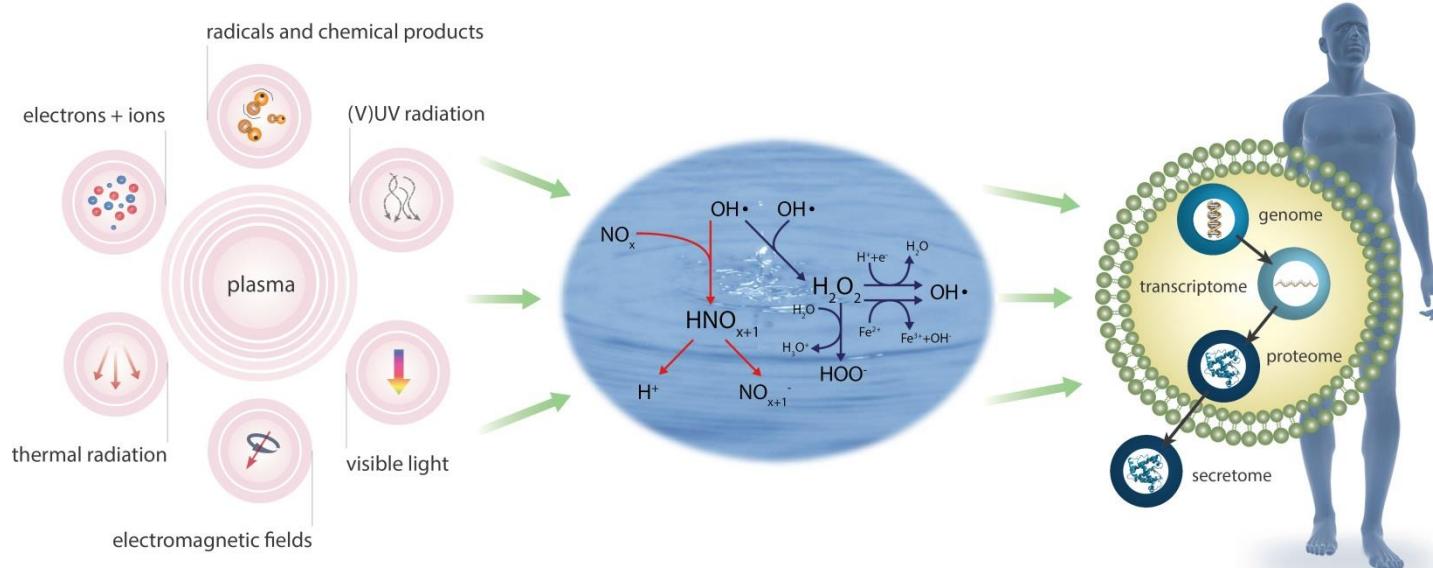
Biological  
Decontamination



## Plasma Sources

# Plasma medicine research

## Plasma Medicine: Application of physical plasma directly on or in the human body



Basic research on the interaction of cold plasmas with physical and biological systems

# Surgical plasma applications

## Argon Plasma Coagulation (APC)

ERBE Elektromedizin GmbH, Tübingen, Germany

Cauterization: tissue destruction,  
burning

- hemostasis
- cutting, removal of tissue

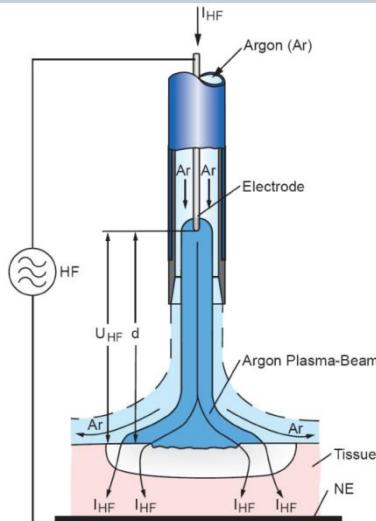


Figure 3: Schematic representation of a typical APC setup. The argon flows through a tube containing the electrode wire. The discharge is ignited by a HF voltage  $U_{HF}$  between the wire end and the tissue. After breakdown, HF current  $I_{HF}$  flows into the tissue, causing a coagulation effect, and back to the HF generator through the neutral electrode (NE).

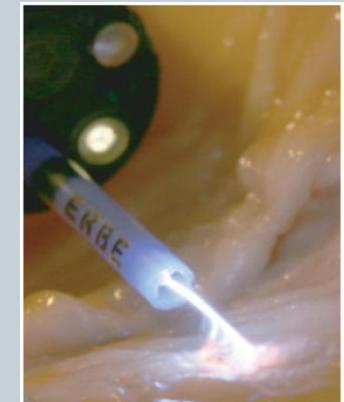
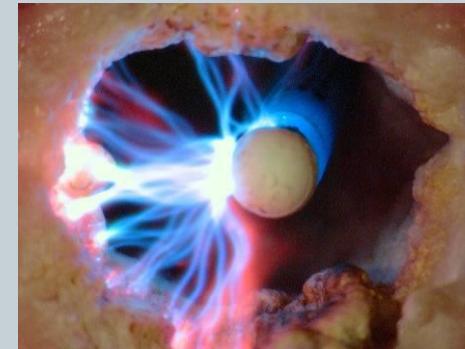


Figure 6: Endoscopic application of APC

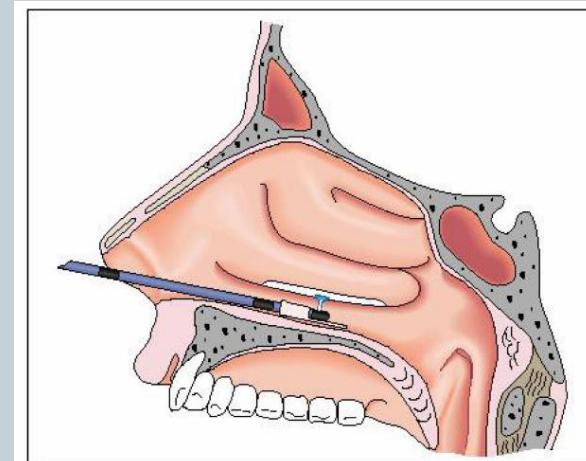
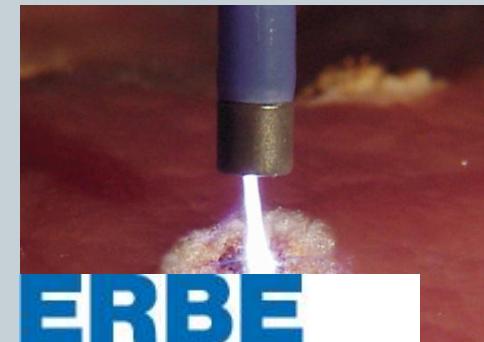


Figure 8: APC in the nasal cavity, where a probe with lateral outlet is used



# Surgical plasma applications

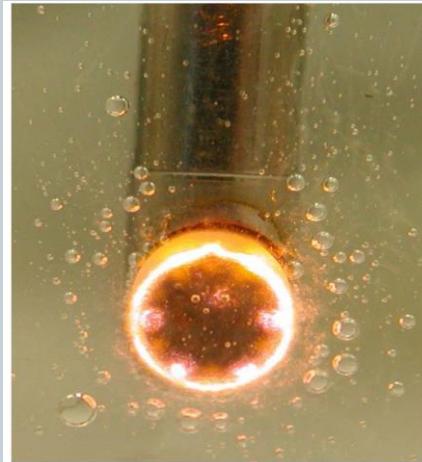


Fig. 1 Photograph of a planar-electrode-type electrosurgical device operating in isotonic saline solution at 300 volts rms. (Online colour: [www.cpp-journal.org](http://www.cpp-journal.org)).

Coblation® (cold/controlled ablation)

ArthroCare Corp., Austin, TX, USA

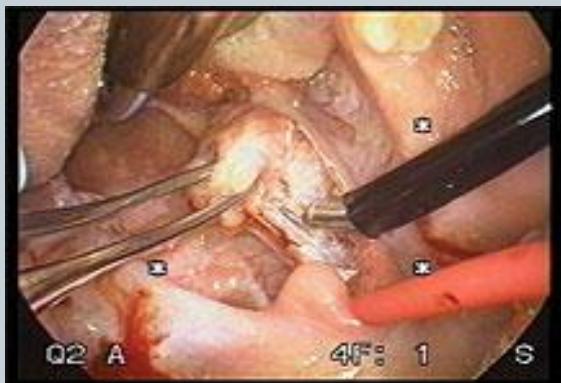
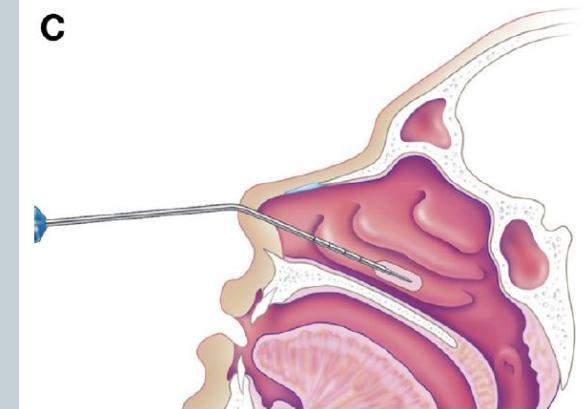


Figure 1 The ReFlex Ultra® PTR Wand (ArthroCare ENT, Sunnyvale, CA). (Color version of figure is available online.)

# Plasma for cosmetics



**Figure 2.** Plasma skin regeneration procedure performed in a paintbrush fashion, holding the handpiece approximately 5 mm from the skin surface. Immediate posttreatment erythema can be seen on the chin. There is no ablation or char formation.



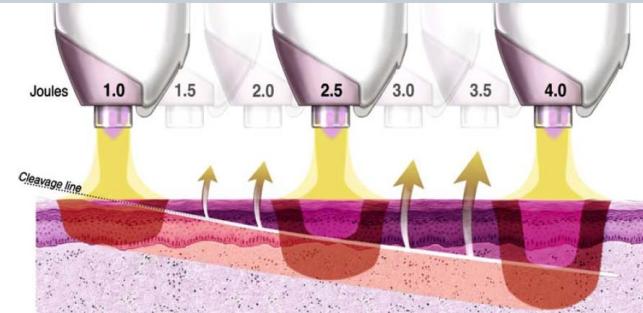
**Figure 3.** Facial appearance before (A) and 3 months after (B) plasma skin regeneration, with improvement in brown mottled pigmentation, improvement in overall skin texture, and subtle tightening at the jowl. Investigator-rated improvement on the 9-point facial hydrt scale changed from 4 (before regeneration) to 2 (after regeneration); patient-rated improvement in overall skin rejuvenation was 85%.



## Plasma Skin Regeneration (PSR): „Portrait® PSR<sup>3</sup> System“ (Rhytec, Inc., Waltham, MA, USA)

RF nitrogen plasma jet

**Fig. 1.** The two zones of effect: the ZTD (purple) and the ZTM (red)



Controlled **thermal** injury and modification:  
ZTD – zone of thermal damage  
ZTM – zone of thermal modification

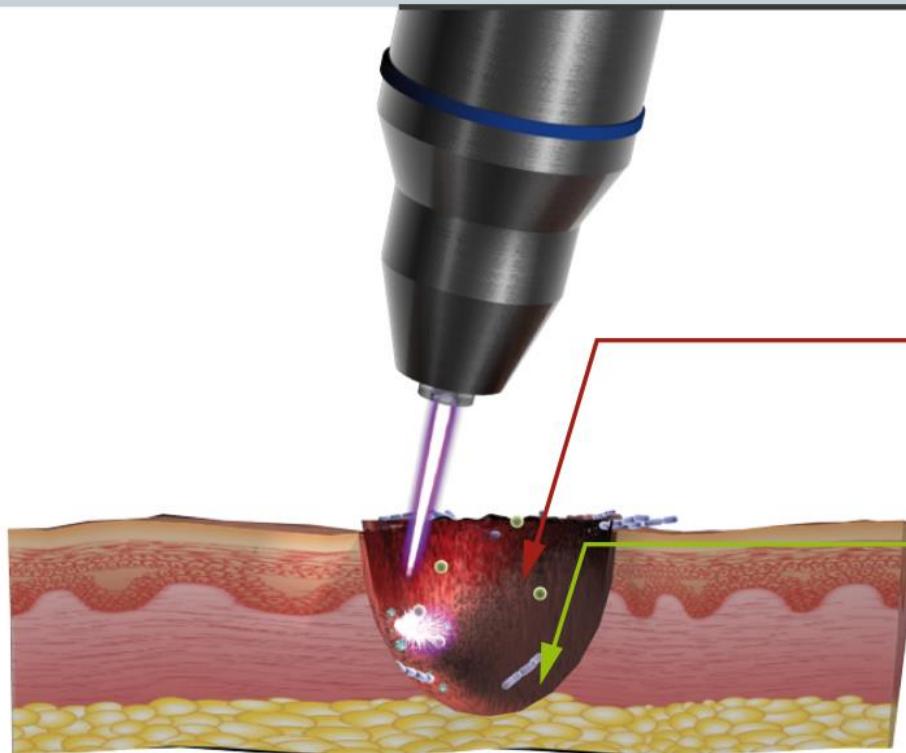
**RHYTEC** TRUE  
REGENERATIVE  
SCIENCE™

# Plasma medicine: (chronic) wound healing



Predominant focus of plasma medicine

## Integrated concept for plasma-assisted wound healing



In vivo antiseptic efficacy + inactivation of endoxins

- Plasma debridement: necrosis + peeling of cell debris including microorganisms

- Stimulation of resorative inflammation

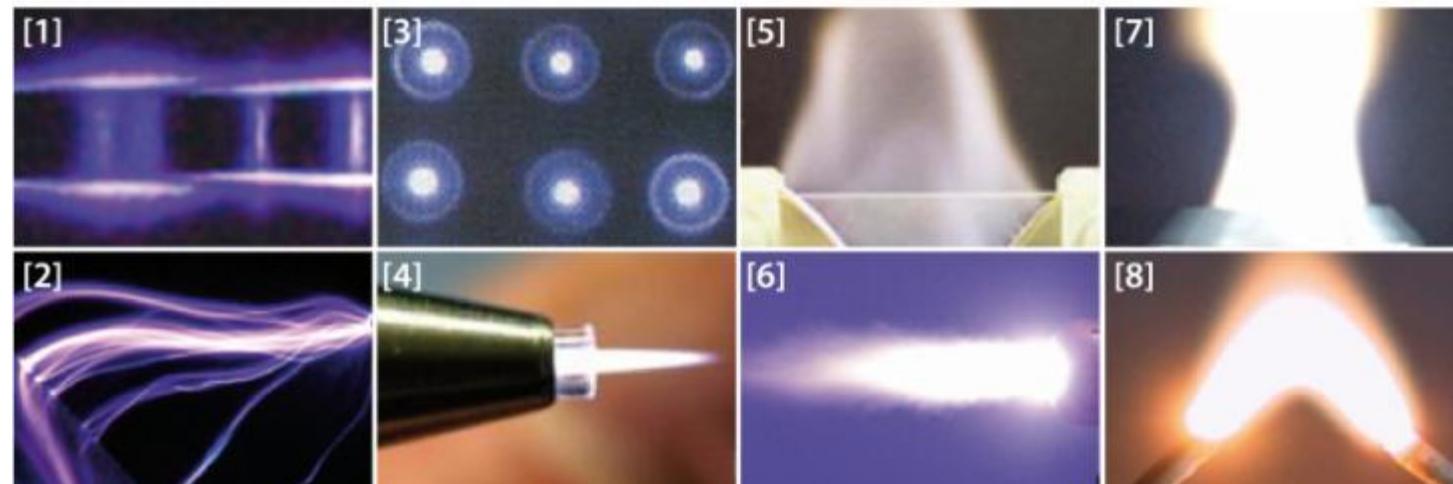
- Stimulation of cell proliferation (fibroblasts, keratinocytes, capillaries)

Superficial cleaning and antiseptics + stimulation of tissue regeneration in deeper layers

# Atmospheric pressure plasmas – „tool box“

Non-Thermal (NT) Plasmas		Thermal Plasmas
“Cold” Non-Thermal Plasmas	Translational (“Hot NT”) Plasmas	
$T_i \approx T_g \approx 300 \dots 400 \text{ K}$ $T_i \ll T_e < 10^5 \text{ K} (10 \text{ eV})$	$T_i \ll T_e \leq 10^4 \dots 10^5 \text{ K}$ $T_i \approx T_g \leq 4 \cdot 10^3 \text{ K}$	$T_i = T_g = T_e$ $T_x < 5 \cdot 10^3 \dots 10^4 \text{ K}$

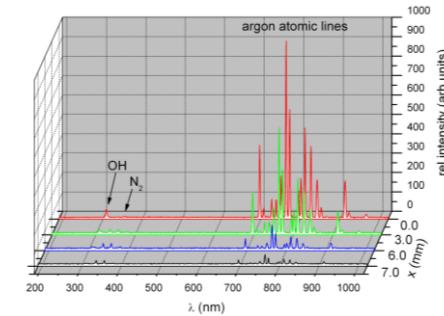
- [1] Barrier discharges
- [2] Coronas
- [3] Microplasmas-Arrays
- [4] Plasma jets
- [5] Gliding Arc
- [6] Arc jet
- [7] Plasma Torch
- [8] Arc



# Before application: Characterization of plasma sources – plasma physics

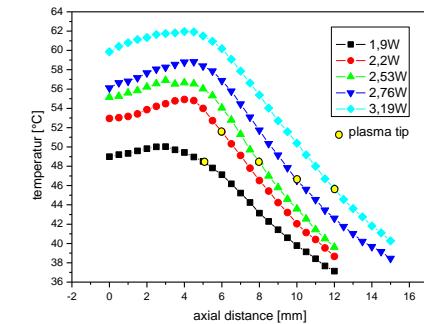
- UV radiation (UVB, UVC)

Parameters: distance [mm], irradiance [ $\text{mW}/\text{cm}^2$ ], operation mode (e.g. continuous, pulsed, burst)



- Temperature

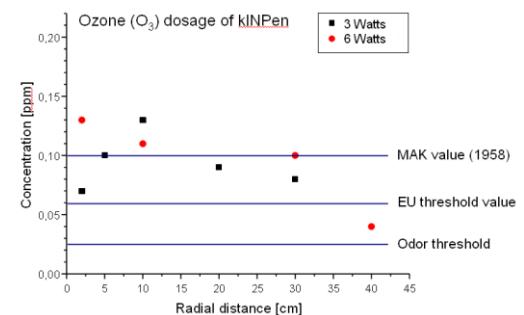
Parameters: distance [mm], power [W], operation mode (e.g. continuous, pulsed, burst)



- Radicals and chemical products (ROS, RNS)

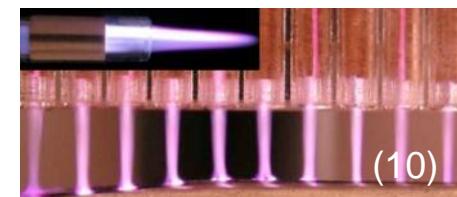
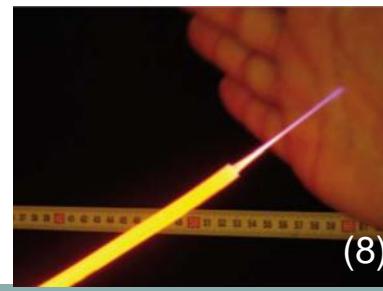
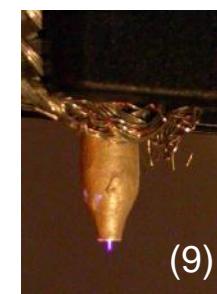
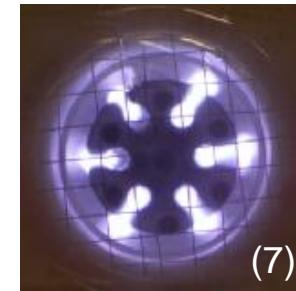
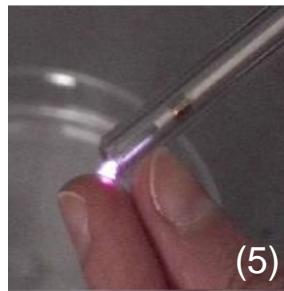
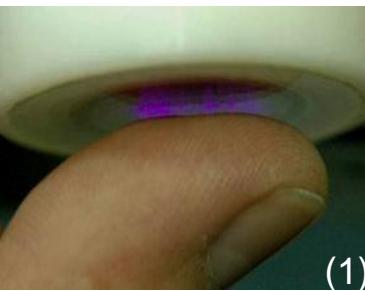
Parameters: distance [mm], power [W], operation mode (e.g. continuous, pulsed, burst), admixture of  $\text{H}_2\text{O}$ ,  $\text{O}_2$ , air

- Ozone ( $\text{O}_3$ )
- Nitric oxide (NO), Nitrogen dioxide ( $\text{NO}_2$ )
- Hydroxyl radical (OH)



Methods: Spectroscopy (OES, FT-IR, TDLAS), Dräger tubes, Fiber-optical temperature measurement

Up to 2010.



- (1) Drexel University (USA)
- (2) Cinogy GmbH (GER)
- (3) Old Dominion University (USA)
- (4) IOM Leipzig (GER)
- (5) Eindhoven Univ. of Techn. (NED)
- (6) New York University (USA)
- (7) MPE Garching (GER)
- (8) University of Orléans (FRA)
- (9) McGill University, Montreal (CAN)
- (10) Loughborough University (UK)
- (11) INP Greifswald (GER)

# Atmospheric pressure plasma jet (kINPen MED)

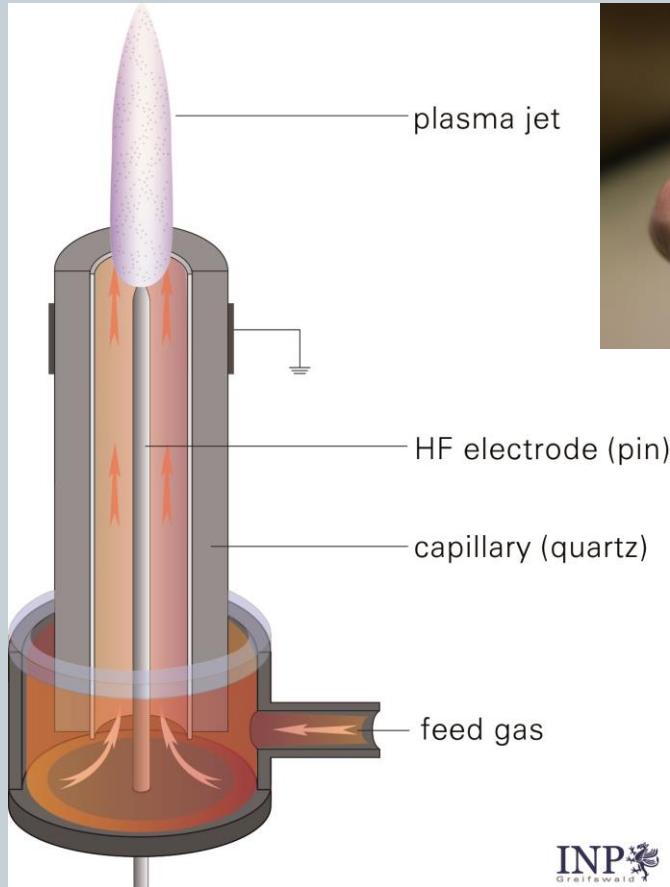
Plasma source for medical application



Certified as **medical device class IIa** (June 2013) according to European Council Directive 93/42/EEC

**Purpose:** Treatment of chronic wounds as well as pathogen-based diseases of skin, skin appendages, extremities and body

# Normothermic atmospheric plasmajet



Dimension:  $L = 155 \text{ mm}$ ,  $\varnothing = 20 \text{ mm}$   
Gewicht: 170 g  
HF-Voltage: 1.1 MHz; 2...6 kV<sub>pp</sub>  
Gastemp.: 30°C ...150°C  
Trägergas: Argon  
Gasfluß: 1...5 sl

K.-D. Weltmann, E. Kindel, R. Brandenburg, C. Meyer, R. Bussahn, C. Wilke Th, von Woedtke, Contrib. Plasma Phys. 49 (2009) 631-640

# Bedside application



# kINPen Med mobile pocket



# CAP and chronic ulcera



H.V., 72years, CHD, IDDM II, PAVD IV, amputation of right lower limb, dialysis, cross-over bypass, DI 0,58

# CAP and intertriginous mycosis



R.R., 77years, AVS, CHD, pre-TAVI

# CAP and fistula (MRSA)



S.T., 66years, CABG 28.02.2014, mediastinitis, closure of the thorax 31.03.2014,  
09.04.2014 sternal fistula with MRSA colonisation

13.05.15 recurrence, 15.05.15 excision, VAC

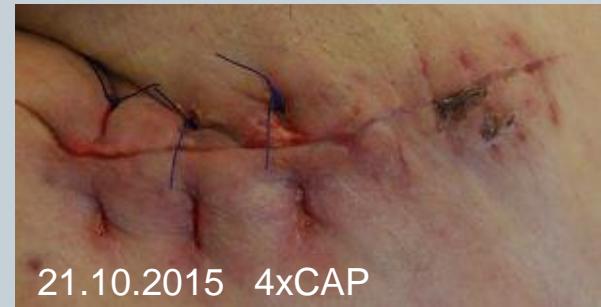
# CAP and surgical wounds I



15.10.2015



19.10.2015 2xCAP



21.10.2015 4xCAP



26.10.2015 8xCAP



09.11.2015

D.S., 75years, ICM, CABG 1996, CRT-ICD, TAVI 23.09.2015, lymphatic fistula, wound revision 10.10.2015, intraoperativ swab: serratia-species, clindamycin, postoperative CAP

# CAP and surgical wounds II



H.R., 68years, ICM, CRT-  
ICD,LVAD 2014, Dyspnoe, PFO,  
19.02.2016 ASD-closure,  
21.02.2016 operative revision of  
an aneurysma spurium with  
hematoma, postoperative venous  
bleeding - Femostop

# CAP – critical ill patients with wounds I



R.F., 78years, AVR  
(stenosis) 23.10.2015,  
Re-Re-Re-Thorax,  
30.10.2015



17.11.2015 after  
conservative therapy



23.11.2015 3xCAP



02.12.2015 8xCAP



# CAP – critical ill patients with wounds II



H.W., 74 years,  
CABG 20.08.14,  
COPD, mediastinitis,  
failed weaning

15.12.2014



27.12.2014 3xCAP

←Only under the  
right breast



11.01.2015 4xCAP

Only under the left  
breast      →

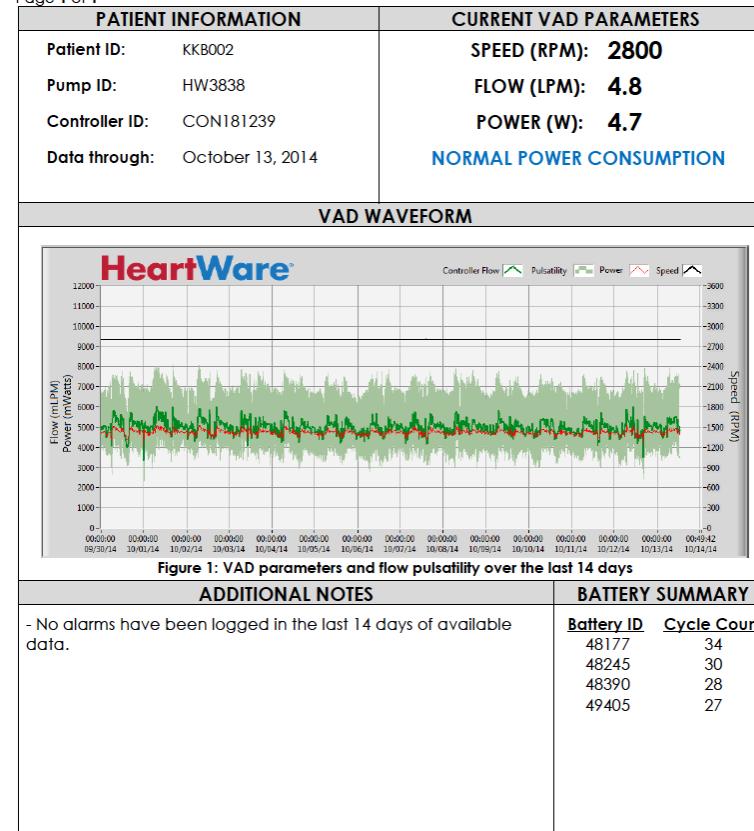


# Impact on the pump function ?



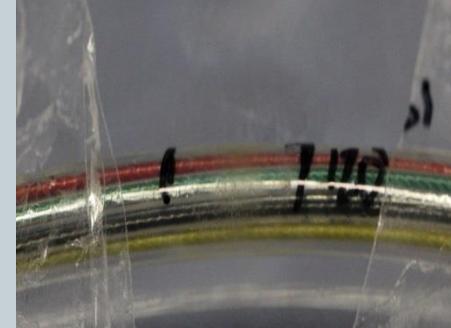
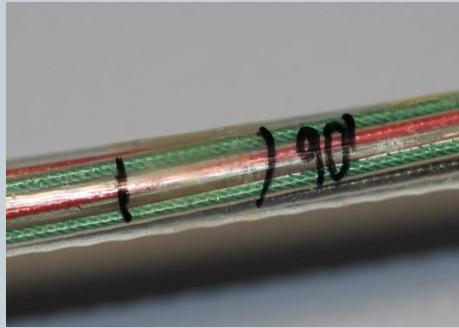
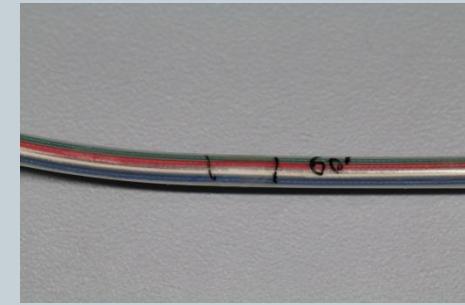
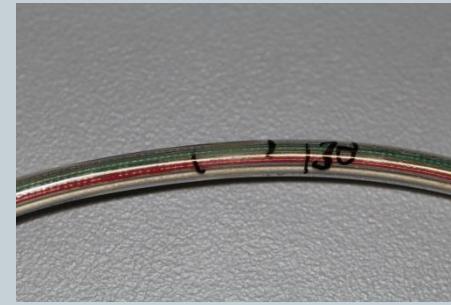
Patient ID: KKB002  
Review Date: October 13, 2014  
Page 1 of 1

**HeartWare®**



This remote analysis has been provided at your request by HeartWare for general informational purposes. It is based solely on log file data provided to HeartWare. HeartWare did not independently validate or verify these log files. This

# Interference with the driveline isolation ?



# Plasma application



# CAP and DI I



W.H. 67years, LVAD HW  
25.03.2013, ICM

# CAP an DI II



W.H. 67 years,  
LVAD HW  
25.03.2013, ICM  
3 month`s later

# CAP and DI III



K.S., 68 years, ICM, HW-LVAD  
11.09.2014, always wet DL-  
wound-dressing

# CAP and DI IV



D.R., 68years, HW-LVAD 08.07.2015, ICM, Adipositas, 24.02.2016 putride secretion and rubor, swab with MRSA, CT without abscess, CAP (13 applications), treatment with linezolid and clindamycin over 4 weeks, signs of bone marrow suppression. Now no signs of inflammation (CRP 12,5 mg/l, Leuco 5,6Gpt/l)

# CAP and DI V



11.11.2014



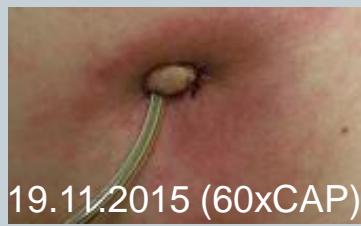
23.04.2015 34xCAP



11.05.2015(postop.d14)



15.07.2015 (44xCAP)



19.11.2015 (60xCAP)



25.11.2015



03.12.2015



15.12.2015



11.03.2016



01.04.2016

D.M., 53 years, HW-LVAD, TVR, PFOC 29.10.2014, ICM, wet DI-exit, 28.04.2015 1.operative DL-Revision / Ampicillin-Sulbactam, 23.11.2015 2.operative DL-Revision /Clindamycin, in the follow up CAP once a week

# CAP and DI VI



Untersuchungsmaterial: Abstrich Wunde oberflächlich  
Abnahmest: Driveline

**Bakterien (aerobe und anaerobe Kultur)** positiv

Kulturergebnis  
K1 reichlich *Staphylococcus epidermidis*

Beurteilung  
Koagulase-negative Staphylokokken gehören zur physiologischen Haut- und Schleimhautflora. Bei einmaligem Nachweis dieser Keime ist eine Kontamination mit Hautflora nicht auszuschließen. Pathogene Bedeutung im Zusammenhang mit einer Fremdkörper-assoziierten Infektion möglich.

ICD Kodievorschlag

Kod-neg. Staph. als Erreger: B05.7 in Kombination mit z. B.  
- Podotraumatische Wundinfektion als Frühkomplikation: T70.3  
- Infektion einer offenen Wunde ohne Fremdkörper: T80.02  
- Infektion einer offenen Wunde mit Fremdkörper: T80.01  
- Wundinfektion nach Amputation: T87.1  
- Wundinfektion nach Amputation: T87.4  
ggf. zu: Phlegmone: L03 - oder Pyodermie: L08.0  
Kodierung der zugrundeliegenden Wunde (G00-T35) nicht vergessen!

Mit freundlichen Grüßen  
OÄ Dr. med. Katrin Schulz

Dieser Befund wurde medizinisch validiert durch OÄ Dr. med. Katrin Schulz und ist auch ohne manuelle Unterschrift gültig.

Antibiogramm	K1			
Cefoxitin Screen	poe			
Induzierbare Clindamycin	neg			
Oxacillin/Fluclaxacill	R			
Ampl-/Ampicillin	R			
Ampicillin+Subactam	R			
Cefuroxim	R			
Cefpodoxim	R			
Cefoxitin	R			
Gentamicin	S			
Co-trimoxazol	S			
Erythromycin	R			
Clindamycin	R			
Doxycyclin/ Tetracyclin	S			
Levofloxacin	R			
Moxifloxacin	R			
Ticoplanin	S			
Vancamycin	S			
Fosfomycin	S			
Fucidinsäure	R			
Linezolid	S			
Rifampicin	S			
Daptomycin	S			
Tigecycline	S			

Legende: S = sensibel I = intermediar R = resistent  
Zahlenwerte = MHK in mg/l (anglehnt an EUCAST)

H.P., 55 years, HW-LVAD 12.10.2014, January 2016 progradient dyspnoe, catheter with RCA-spasm, TEE AI I, April 2016 accidental tug to the DL, pain syndrom, analgetics inclusive carbamazepin with short effect, in May readmission, now fistula (Staph. epi.), 06.05.2016 operative DL-exit-revision. intraop. CAP, 26.05.2016 readmission with progradient dyspnoe, TEE no endokarditis AI II, TI II-III, HU-TX?

## Makroskopischer Befund:

2,7 x 1,7 x 0,7 cm großes Hautexzidat.

## Mikroskopischer Befund:

Haut-/Unterhautgewebe, an der Oberfläche von gut differenziertem Plattenepithel überkleidet und randlich in einem offensichtlichen ulzerösen Defekt übergehend mit Fibrinbelägen und schüchterner bis mäßiger granulozytärer Demarkation. Darunter ein ödematoses sowie stärkergradig fibrosiertes Stroma mit schüchterner bis mäßiger gemischter Entzündungszellinfiltration. Keine Atypien.

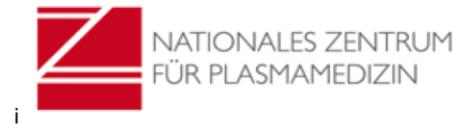
## Diagnose:

Haut-/Unterhautgewebe mit ulzeröser florider granulierender und stärkergradig fibrosierender Entzündung. Kein Anhalt für Malignität.

Prof. Dr. med. Klaus Hamper

# CAP and DI IV





**Studienprotokoll**

< KBGWZP 1/2015 >

## **Plasma in Superficial Driveline Infections Trial**

**Prospektive multizentrische Anwendungsbeobachtung zur Therapieoptimierung  
oberflächlicher Infektionen der Austrittstellen von Drivelines bei LVAD-Patienten mittels  
Atmosphärendruck-Plasma**

Kurztitel: **PLASDIT**

Herkömmliches Wund Management unter Antibiotikatherapie gegenüber gleicher Therapie + lokaler  
Anwendung von Athmosphärendruck-Plasma unter Nutzung des Kinpen Med

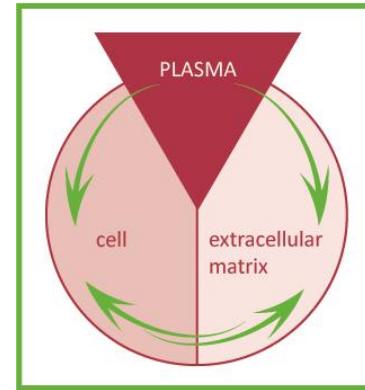
Sponsor: Fa. HeartWare, Fa. neoplas tools GmbH

Studienleiter:

Studienkoordinator: .....

# State of knowledge: Plasma-cell interactions

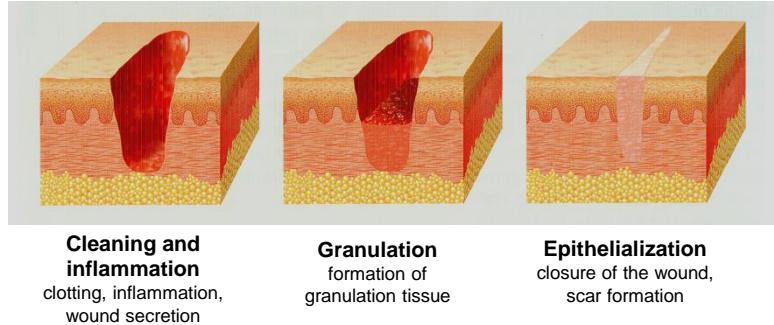
1. Biological plasma effects are significantly caused by plasma induced changes of the **liquid environment** of cells



2. Dominating role of (non-charged, stable) **oxidizing** species
  - transferred and/or generated into/in the liquid environment of cells
  - being able to act inside the cells
3. Active agents (mammalian cells): plasma-generated ROS
  - low ROS doses: stimulation of cellular functions
  - high ROS doses: apoptosis
4. Active agents (microorganisms): plasma-generated **RNS/RONS** and acidification

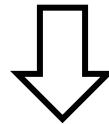
# ROS and RNS in cell physiology

## Wound healing

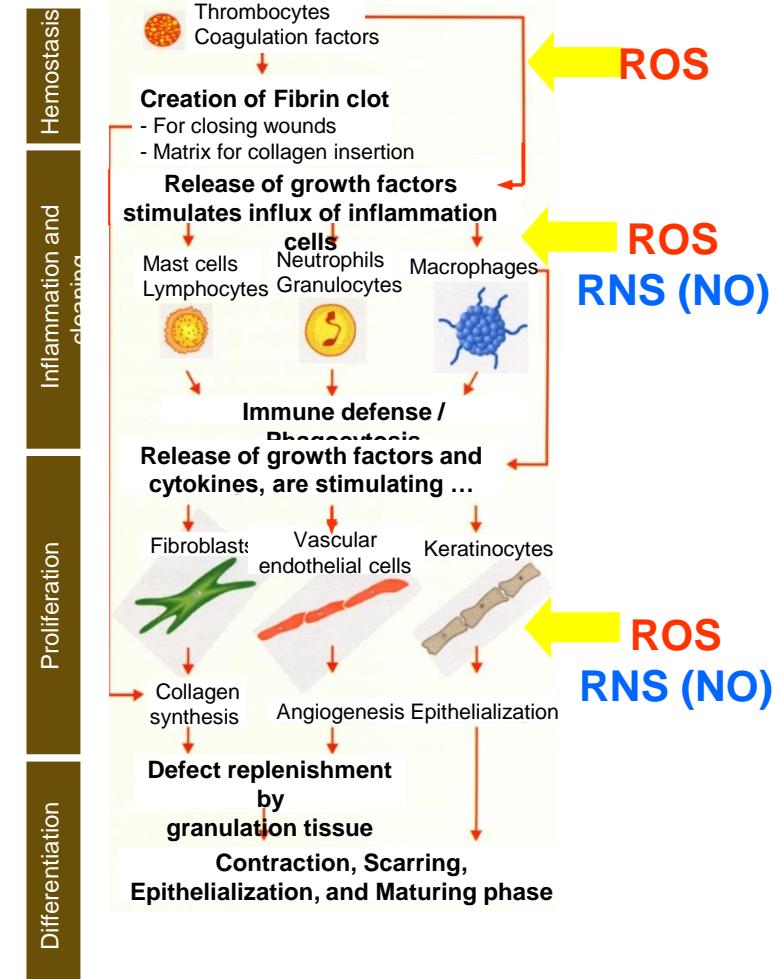


## Redox-based wound therapy

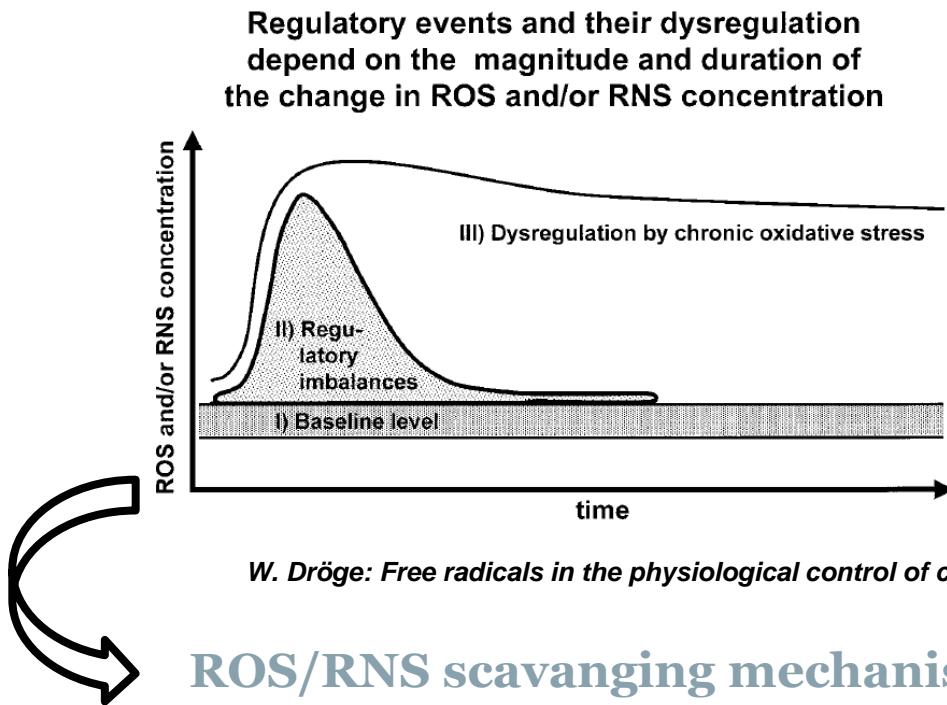
Ch. K. Sen et al., *Biochim. Biophys. Acta* 1780 (2008) 1348-1361  
Ch. K. Sen, *Wound Rep. Reg.* 17 (2009) 1-18



Scientific basis of plasma-supplemented wound healing



# ROS and RNS in cell physiology



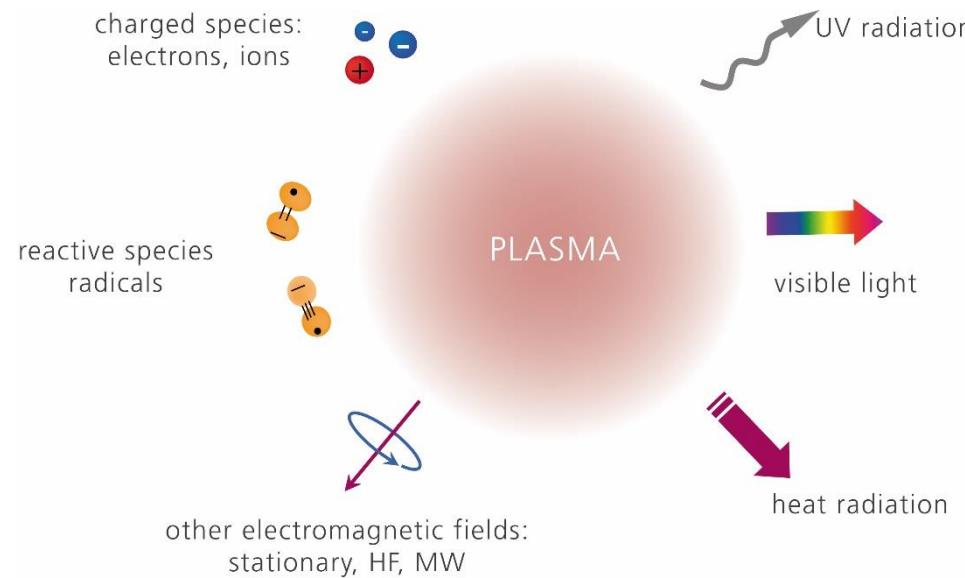
## ROS/RNS scavenging mechanisms *in vivo*

Because its localized and short-term generation by local plasma treatment these substances can be detoxified by processes of regular cell metabolism.

The risk of plasma application is assessable and manageable

# Plasma application: main advantages

- active components are generated locally and only for the required duration of the application by powering a not directly effective gas (argon, helium, oxygen, nitrogen, air, or mixtures thereof, respectively) using electric energy
- the individual physical and transient chemical active components not only complement and strengthen one another through synergistic activities, but can partly replace each other



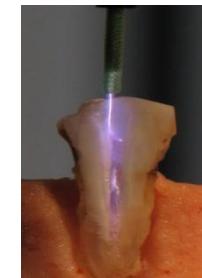
# Summary and Outlook

- An increasing number of (prototype) plasma sources for life science is available from various research institutes and universities
- The level of physical and biological characterization of the plasma sources is very different
- For a successful market introduction a minimum set of investigations has to be done before one can state „....also useful for medical applications“
- Up to now, there is no big player on the (plasma-medicine) market
- Small companies entering the market often within the field of cosmetics
- Three companies in Germany meanwhile with certified medical product
- Each medical indication needs a special taylored plasmasource
- Food decontamination by plasma seems to become another field of growing interest besides plasma-pharmacy, plasma-biology.....

# Medical applications of plasma

The status quo of plasma medicine foresees the following medical application areas for cold plasmas at atmospheric pressure:

- (external) plasma applications on body surfaces (skin, mucous membrane, wounds, teeth)
- plasma applications at open surgical treatment
- plasma applications in visceral cavities (endoscopic)



# Plasma Medicine: Future prospects

- Application-adapted plasma sources
- Basic research on plasma-cell and plasma-tissue interaction with focus on safety of plasma application
- Clinical trials with focus on safety of plasma application as well as proof and consolidation of therapeutic applications
- Development of further fields of medical plasma use:
  - New targets: cancer treatment
  - New sites: teeth, lung, gastrointestinal tract, eyes, ...



# What is the problem ?



Until now no reimbursement

# What is in the Pipeline?



- Plasma Plaster

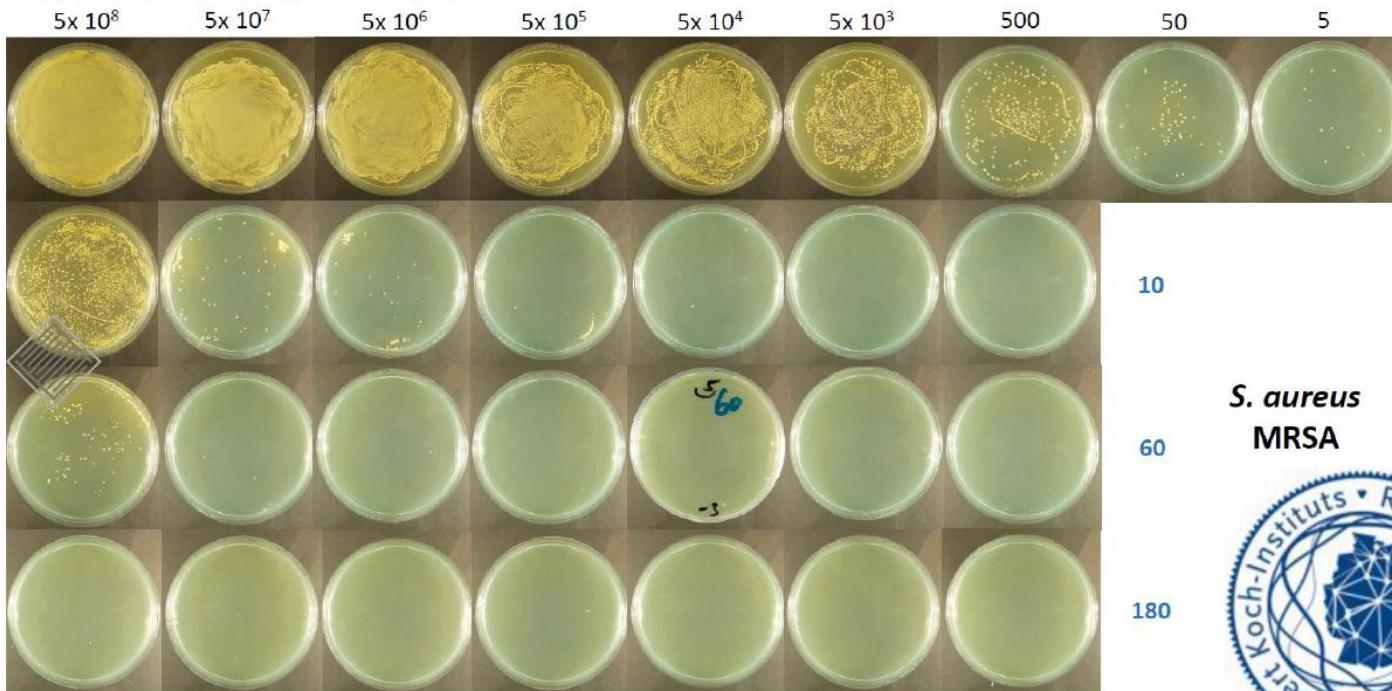


COLD PLASMA TECH

# CAP Plaster – biological efficiency



approximate cell count given to the plate



10

*S. aureus*  
MRSA



60

180



COLD PLASMA TECH

# CAP – further education



NATIONALES  
ZENTRUM  
FÜR PLASMAMEDIZIN e.V.

## EINLADUNG

### Workshop

Vorstellung klinischer Erfahrungen in der Plasmamedizin

Das **Nationale Zentrum für Plasmamedizin** ([www.plasma-medizin.de](http://www.plasma-medizin.de)) ist das deutschlandweite Netzwerk auf diesem Gebiet. Der Verein wurde 2013 gegründet und führt seitdem die maßgeblichen Akteure in Klinik, Forschung und Industrie zusammen, um aus gemeinsamer Kompetenz und Verantwortung heraus die Forschung und Entwicklung in diesem Bereich voran zu treiben.

In diesem Workshop wollen wir einen Überblick über die bisherigen klinischen Erfahrungen innerhalb der Plasmamedizin geben und diese mit Vertretern aus Praxis, Industrie und Forschung diskutieren.

Dazu sind Sie herzlich eingeladen!

**Wann:** 28. und 29. Juni 2016

**Ort:** Vertretung des Landes Mecklenburg-Vorpommern beim Bund  
In den Ministergärten 3 // 10117 Berlin

**Die Veranstaltung ist für Mitglieder kostenfrei.**

Nicht-Mitglieder des NZPM zahlen einen Kostenbeitrag von 40,-€  
(Mittagsbuffet inbegriffen).

10.-11. Mai 2017 in Hamburg

**28. Workshop**  
**Oberflächenfunktionalisierung von**  
**starren und flexiblen Materialien**

13.-14. September 2017  
in Rostock/Mecklenburg-Vorpommern

**29. Workshop**  
**5. Plasmamedizin-Workshop**  
**Therapeutischer Einsatz von**  
**physikalischen Plasmen**  
Neue Erkenntnisse aus Physik, Medizin und Biologie

15.-16. November 2017 in Jena/Thüringen

**30. Workshop**  
**Verbesserte Haftung durch**  
**Plasma(vor)behandlung**

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Erstellung und Gestaltung: INNOVENT e.V.



## 6<sup>th</sup> international conference on plasma medicine

**icpm<sup>6</sup>**

September 4-9, 2016 - Bratislava, Slovakia



associated with  
Summer School on Plasma Medicine - September 1-3, 2016

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## Welcome

On behalf of the International Society for Plasma Medicine (ISPM), we are delighted to welcome you to the full-week 6th International Conference on Plasma Medicine (ICPM-6), which will be held in Bratislava, Slovakia, from September 4 to 9, 2016.

Plasma Medicine is a new, rapidly growing field that faces many technological challenges and brings to the forefront fundamental questions on the mechanisms of interaction between living organisms and gas plasmas. The conference creates a multidisciplinary forum bringing together professionals from the fields of plasma physics, medicine, biology, biochemistry, pharmacy, agriculture, and food science and industry, in order to develop a common language, to better define key challenges and open questions, to further development of international collaborations, and to move toward effective solutions.

This time, the ICPM-6 will be preceded by the ISPM Summer School on Plasma Medicine.

We hope to see you all in Bratislava, one of the pearls on the Danube river and quickly developing metropoles in the Central Europe.

Zdenko MACHALA and Karol HENSEL  
Organizers of ICPM-6

**SUMMER SCHOOL  
on Plasma Medicine**

**ICPM-6 user account**

### Recent News

2016-04-25  
Post-deadline abstract submission announced  
2016-04-25  
List of companion trips added.  
Conference dinner venue added.

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# CAP – further clinical research



- 22.02.2016 start-up of the Diabetes Innovation Center Karlsburg - clinical treatment and applied research



# Coming soon

The book cover features a blue background with a red vertical bar on the right side containing the title. At the top, there is a decorative circular graphic. The title 'Plasma-medizin' is prominently displayed in large white letters, with 'Kaltplasma in der medizinischen Anwendung' underneath it. The authors' names are listed above the title. On the left, there is a detailed description of the book's content and a list of included topics. At the bottom left is a barcode and the Springer logo.

**Plasmamedizin**

Dieses Buch beschreibt die Einsatzmöglichkeiten von modernen Plasmageräten in der Medizin. Die Grundlagen der Methode und die Technologie unterschiedlicher Geräte werden erläutert. Kaltplasma ist antimikrobiell wirksam und stimuliert die Gewebe-regeneration und die Durchblutung. Aus den Behandlungsmöglichkeiten von Wunden, Ulzera und auch Tumorzellen mit Plasma ergeben sich viele Einsatzoptionen in der Dermatologie, der Zahntechnik, der Chirurgie und der Hygiene. Aktuelle Forschungsarbeiten bieten einen Ausblick auf den Anwendungshorizont in unterschiedlichsten Fachgebieten. Kapitel zur Abrechnung und zur Weiterbildung in der Plasmamedizin vervollständigen den praktischen Ansatz des Buches.

Aus dem Inhalt:

- Wissenschaftliche Grundlagen der Plasmamedizin
- Antimikrobielle Einsatzmöglichkeiten
- Behandlung von Wunden und Ulzera
- Einsatz von Plasma in der Chirurgie
- Plasma in der Zahntechnik und der Kieferorthopädie
- Ästhetische Plasmamedizin
- Einsatzmöglichkeiten in der Immunologie
- Wetterbildungsgeräte
- Abschmiegtechniken
- Plasmageräte

Die Herausgeber:

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ISBN 978-3-642-32666-8  
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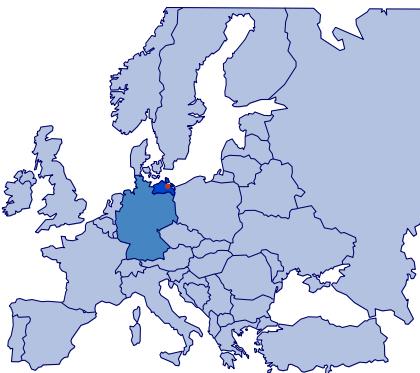
Plasma-medizin

Kaltplasma in der medizinischen Anwendung

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# Acknowledgement & contact

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HERZ- UND DIABETESZENTRUM



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IN DEN NEUEN LÄNDERN

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 **plasmatis**  
Plasma plus Zelle