PROF. DR. KLAUS-DIETER WELTMANN,
DIRECTOR OF THE LEIBNIZ INSTITUTE FOR PLASMA SCIENCE AND TECHNOLOGY E.V.

Klaus-Dieter Weltmann received his diploma degree in electronics and his doctorate (Dr. rer. Nat.) in applied physics from the University of Greifswald, Germany in 1989 and 1993, respectively. His work focused on nonlinear dynamics in low temperature plasmas and plasma diagnostics. In 1994 he was a visiting scientist in the Plasma Physics Laboratory at West Virginia University. In 1995 he joined ABB Corporate Research Ltd., Baden-Dättwil, Switzerland, where he worked on the development of high voltage (HV) and medium voltage (MV) switchgear. In 1998 he became the head of High Voltage Systems Group, ABB Corporate Research Ltd. In 2000 he was appointed to lead R&D of Gas Insulated Switchgear (GIS, PASS) at ABB High Voltage Technologies Ltd., Zurich, Switzerland, where in 2002 he became Business Unit R&D Manager GIS. Since 2003 he has been in charge of the Leibniz Institute for Plasma Science and Technology e.V. (INP Greifswald). His present research interests include MV and HV switchgear, gas discharges at atmospheric pressure, nonlinear dynamics, and plasma medicine.

Prof. Weltmann, at the INP Greifswald plasma medicine research focuses on plasma decontamination and cell treatment. What breakthroughs do you anticipate in these research areas?

To begin with, I would like to subdivide plasma medicine into three research fields based on plasma decontamination and cell treatment: surface modification; biological decontamination/sterilization; and therapeutic applications.
In the field of bio-relevant surfaces, plasma treatment improves the biocompatibility of implants such as bone implants, tendons and ligaments, vascular grafts, stents, heart valves, etc. by increasing their antifouling and bacteria-repellent properties on the one hand. On the other hand, the surface will retain its adhesivity for human cells to guarantee a fast tissue ingrowth without complications. At a present average implant life time of about 10 years and volumes of e.g. 1 million hip joints per year, as well as 250,000 knee replacements etc., better surface properties will continuously improve the life time of implants, cause fewer additional operations, drugs, painkillers, reduce the amount of time spent in medical rehabilitation, and improve the patients' quality of life.
Due to the development of cold plasma sources working at ambient air, the treatment (decontamination/sterilization) of heat sensitive materials and medical devices will be significantly improved or even become possible, as, for example, the reprocessing of endoscopes and catheters. In addition, such devices can be coated by plasma to achieve better antimicrobial properties than before; plasma can be used inside of endoscopes for new therapeutic applications in surgery or even lead to a reuse of some of today's disposable goods, thus saving money.

First therapeutic applications in dermatology, dentistry or direct wound healing showed promising results. Individual in-patient treatments recently showed the decontamination of chronic wounds, thus leading to improved wound healing, as well as the successful treatment of infectious skin diseases like dermatomycoses or acne. In the near future, I expect a huge development of hand-held and large-scale clinical devices adapted to different special applications on the market. The development could be similar to laser medicine years ago.

Which areas of plasma medicine do you consider the most developed, and which are the most promising?

Certainly, the field of surface treatment is at the moment the most developed area, followed by plasma assisted decontamination and sterilization. Due to its incredible high speed of development and the unbelievable growing interest from science and industry, the direct therapeutic applications with a focus on wound healing will be the most promising but also the most risky. The other two fields harbor much lower risks.
The treatment of chronic wounds and local cancer treatment are key fields for potential plasma applications in addition to the aforementioned skin infections.

What opportunities and risks do you see in the treatment of diseases, such as chronic wounds, skin and mucosal infectious diseases, and localized tumors with tissue tolerable plasma?

At the moment I would say that opportunities and risks are balanced. Yet more and more risks have been addressed recently and investigated all over the world, therewith decreasing the number of risks day by day.
Two basic aspects have to be guaranteed first: an effective, complete and sustainable inactivation and/or removal of disease-causing microorganism cells or cancer cells, respectively, and a simultaneous protection of surrounding healthy tissue. As expected, the same mechanisms will, in principle, influence cells. Therefore, dose-dependent plasma effects must be very carefully characterized to guarantee selectivity of plasma treatment and to prevent both sub-effective and tissue-damaging treatments. Especially in the case of cancer treatment, sub-effective treatment would involve the danger of metastasis.
We have to distinguish between the basic research that is carried out to understand the interaction between plasma and living tissue and the development of application-oriented plasma sources. If one scrutinizes the field, scientific talks, and papers, the situation is reminiscent of the early days of plasma processing of semiconductors in the late 1980s. Applications are driving the field, while the basic scientific understanding is woefully lacking and efforts to catch up are lagging behind. In the early 1990s, it took several efforts to bring the scientific community on board and into a beneficial dialogue with the practitioners. Ultimately, the field developed in a rational fashion with a healthy balance between efforts devoted to

advancing the field of applications and efforts devoted to advancing basic scientific understanding. Plasma medicine is at this point right now. Several reviews have appeared recently that focus on the exciting applications, but do not pay proper tribute to the importance of addressing the many underlying basic science questions. Some manufacturers offer their devices as fit for medical use without having them characterized and tested for this application in the necessary detail. This clearly is a risk for the whole new field of research in case that such devices will be used for purposes what they are not intended for or not even carefully tested. However, up to now, there are no generally accepted criteria according to which cold plasma sources can be assessed as to their suitability for medical applications. Consequently, from my point of view, a necessary next step is to establish a mandatory set of basic plasma physical and biological performance parameters including specific effects on human cells and to transfer them into legal rules and standards including a risk analysis considering different fields of potential application.
Only a well-tuned concept of combination of interdisciplinary basic research and application-oriented research on specific clinical use of plasma will put the plasma-medical research community in a position to take responsibility to respond to the legitimate public expectations without inspiring the hope of short-term and easy-to-get solutions of all medical problems including healthcare costs.

How closely does your institute collaborate with institutes and researchers in the U.S.?

We have a very close collaboration with the Polytechnic Institute of New York University (NYU-Poly) and the NYU College of Dentistry in the field of plasma medicine for dental applications for several years. Furthermore, the development of new plasma sources for various applications in industry and medicine is a frequent topic for my yearly visits as a guest professor at NYU-Poly. Direct contacts to Drexel University – the pioneer of plasma medicine – exist as well as a long- lasting cooperation with the Frank Reidy Research Centre for Bioelectrics in Norfolk.

How do you see the market potential for plasma medicine in Germany and in the U.S.?

According to BCC Research, there is a total market for wound care in 2011 (wound care dressings, sealants and anti-adhesion products) of about $ 2.5 billion, in addition to about $ 2 billion for wound healing devices, whereas 35% is covered by the US market and 46% by Europe. Here, no plasma based devices or plasma-supported therapy except the classical electro surgery is taken into account. A remarkable part of that market can be addressed by the new plasma devices and plasma-based or supported therapeutic applications e.g. in wound healing, dermatology, dentistry and surgery as well as in veterinary medicine and in addition the market for cosmetics.