

UNCLASSIFIED

Defense Technical Information Center
Compilation Part Notice

ADP014965

TITLE: Interpretation of the Current Signal Collected from Surface Barrier Discharge Electrodes

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: International Conference on Phenomena in Ionized Gases [26th]
Held in Greifswald, Germany on 15-20 July 2003. Proceedings, Volume 4

To order the complete compilation report, use: ADA421147

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:

ADP014936 thru ADP015049

UNCLASSIFIED

Interpretation of the current signal collected from surface barrier discharge electrodes

D. Korzec, E.G. Finantu-Dinu, J. Engemann

Forschungszentrum für Mikrostrukturtechnik-*fmt*, University of Wuppertal,
Rainer Gruenter Straße 21, 42119 Wuppertal, Germany

The current signal measured at the grounded electrode of the surface barrier discharge (SBD) excited in the frequency range 1-10 kHz is typically distorted by electric circuitry oscillations in MHz range. Numerical techniques for extraction of the partial discharge (PD) current signals with durations in ns range are proposed.

1. Introduction

The surface barrier discharge (SBD) [1] and insulated surface barrier discharge (ISD) [2] are very promising types of dielectric barrier discharges (DBD). Their main applications are ozone generation [1], exhaust gas decomposition [3] and more recently surface treatment and film deposition at atmospheric pressure [4]. The electrical measurements [5] show strong influence of excitation voltage and frequency, electrode layout and coating material on the PD development. The measured current represents the response of the electric circuitry connected to the electrode on the discharge current. In this work the method for determination of the discharge current from the measured current is proposed. It is based on the fast FOURIER transform (FFT).

2. Experiment

The discharge system described in detail in [5] consists of two electrodes separated by 0.4 mm thick, high purity Al_2O_3 ceramic plate. The surface of the discharge electrode is coated by diamond like carbon (DLC) or polymeric film. On the opposite side the induction electrode is formed as a 70 mm $\times$ 50 mm rectangle. A sinusoidal voltage with a frequency of 3.7 kHz and amplitude in range 2-5 kV is applied between the electrodes. For current measurements the digital oscilloscope Tektronix TDS 7254 with a high frequency AC current probe CT6 is used.

3. Results and discussion

The typical current waveform for DLC coated ISD electrode is shown in Fig. 1a. The "spikes" easier recognizable in magnification shown in Fig. 1b, are related to partial discharges (PD) but show the PD currents overlapped with oscillations in MHz range [5]. These oscillations are interpreted as response of the RLC circuitry connected to the discharge electrode on

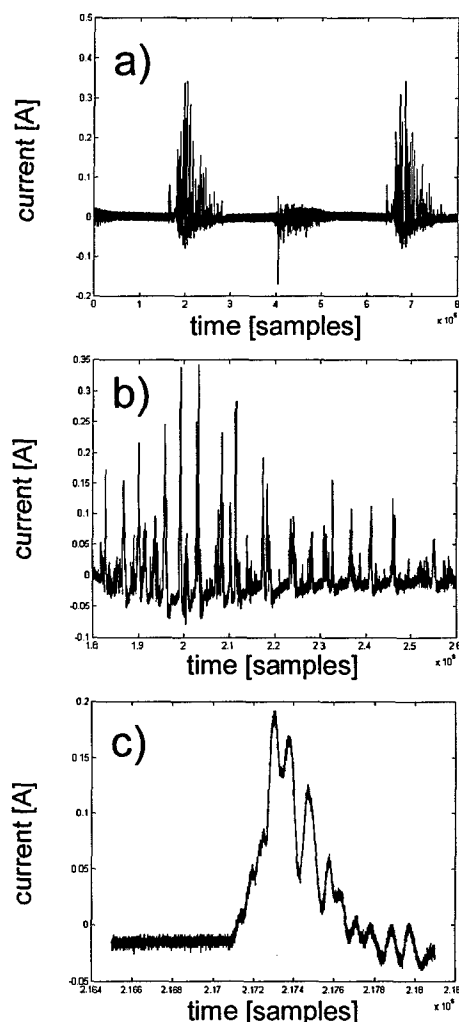


Fig. 1: Typical current signal of ISD in 10% oxygen + 90% nitrogen gas mixture at 700 mbar. a) Entire excitation cycle, b) signal segment and c) PD response of the circuitry. Sample = 0.1 ns. Coating: 1 μm DLC.

the PD current. Assuming a DIRAC pulse excitation put on the serially connected resistance R, capacitance C and inductance L, the response of the circuit is given as:

$$g(t) = \frac{1}{\sqrt{LC}} \exp\left(-\frac{R}{2L}t\right) \sin\left(\frac{t}{\sqrt{LC}}\right)$$

One of parameters having strong influence on the oscillation frequency is the length of wires connecting the electrode system to the coaxial cable. In Fig. 2 the examples of the PD signal for two different connection

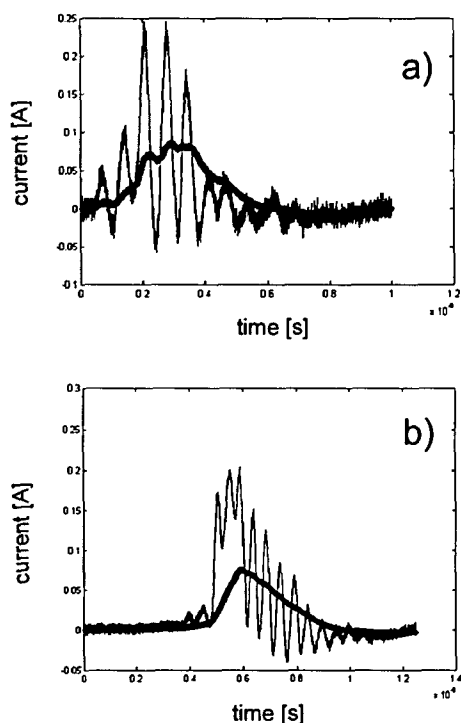


Fig.2: The response of the circuitry for two oscillation frequency a) 16.8 MHz to b) 20 MHz, due to different lengths of wire connections to the electrode.

wire lengths are shown. For technically useful electrode geometries it is not possible to eliminate the electric connections inductance completely. The measured

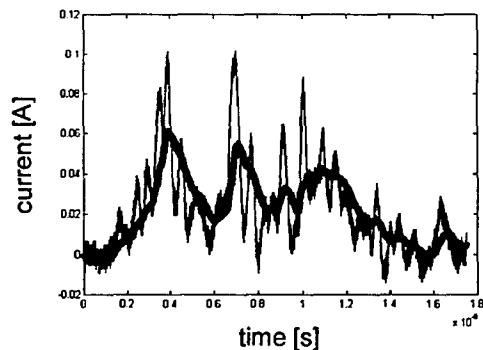


Fig.3: Deconvoluted current signal for overlapping PDs.

current of single PD can be considered as a convolution of the real PD current and the circuit response on DIRAC impuls. In such case the real PD current can be obtained following the algorithm presented graphically in Fig. 4.

In first step the FFT of the measured signal $x(t)$ and of the damped RLC-oscillation $g(t)$ are calculated. Then the signal transform $X(f)$ is divided by the oscillation transform $G(f)$. From the result the inversion FOURIER transform (IFFT) is determined, which gives the real PD current $Y(t)$. Also overlapping signal of subsequent PDs can be de-convoluted by use of this scheme (see Fig. 3).

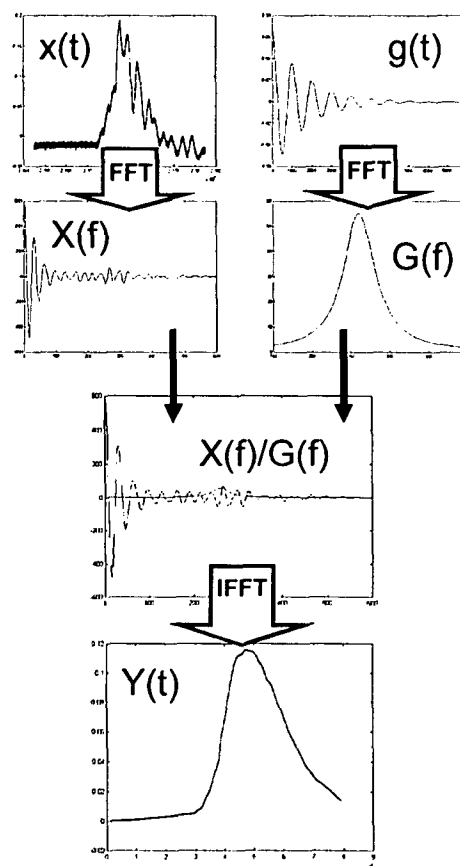


Fig.4: Principle of numerical removal of the electric circuit oscillation from the measured current signal.

References:

- [1] S. Masuda et al, *IEEE Tr. Industry Appl.* **24** (1988) 223.
- [2] D. Korzec et al, *Asian European Plasma Surface Engineering AEPSE 2001*, Nagoya, Japan.
- [3] S. Masuda et al, *IEEE Tr. Industry Appl.* **29** (1993) 781.
- [4] Štefečka et al, *Proc. XXV ICPIG*, Nagoya, Japan, 17-22 July 2001, Vol. 4, pp. 45-46.
- [5] E. Finantu-Dinu et al, *PSE 2002*, Garmisch-Partenkirchen, September 9-13, 2002.