Sub-nanosecond development of electrical current in argon barrier discharge at atmospheric pressure

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Barrier discharges are plasma sources widely used in fundamental as well as application-oriented research [1]. The most common basic diagnostics of such discharges is by electrical measurements. Using appropriate approaches on various types of barrier discharges one can obtain a large amount of information by analysing just the electrical signals, i.e. the applied voltage and the electrical current. Determination of implicit parameters of the plasma in the gas gap, like effective electric field or transferred charge etc., can be made based on different equivalent electrical circuit models. Nevertheless, at the beginning, there is the necessity to have the right input data, e.g. the current and the voltage have to be measured with high sensitivity and high temporal resolution to enable further complex analysis [2].

In this contribution, we perform precise measurements of the electrical current using a transverse electromagnetic (TEM) cell. We measure the electrical current of a barrier discharge in argon at atmospheric pressure. Using these measurements we intend to validate the results of a time-dependent and spatially two-dimensional fluid-Poisson model made for a similar setup [3].

Typically under given conditions, the experimental validation of numerical results requires current measurements at sub-ns time scale. This is highly challenging mainly because the wavelength corresponding to the rapidly changing signals on (sub)-nanosecond time scale becomes comparable with the apparatus dimensions and the attenuation and phase shift on various parts of the apparatus significantly affects the measured current profile. This can cause two main issues: reflections of the transient signals on impedance jumps and deformation of the signal profile.

To avoid reflections from unmatched power supply, a long coaxial cable between power supply and the discharge chamber was introduced (see e.g. [5, 6]). This gives us several tens (depending on the coaxial length as well as the used dielectric) of ns of manifestly reflection-free signal. Similarly, long coaxial cables can be used between measuring probe and oscilloscope. The discharge itself was placed into a TEM cell [4] that is properly matched to coaxial cables (checked by time domain reflectometry). The measurement of S-parameters by a vector network analyser can be used to properly measure the attenuation and phase shift of individual components [6]. Another potential possibility for transient events could be direct measurement of peak response function in time domain and (de)convoluting the measured signal to reveal the correct current profile.

Here, we present the first results of testing measurements. Fig. 1 (left panel) shows the current peak profile of a volume dielectric barrier discharge (VDBD) in half-sphere to plane configuration, where both electrodes are covered with alumina. The right picture in Fig. 1 shows the TEM cell connected to HV coaxial cables. The alternating voltage (6.28 kHz, sinusoidal) is on the central conductor (septum). The current probe consists of electrode covered by alumina, 50 Ω resistor and SMA coaxial connector.

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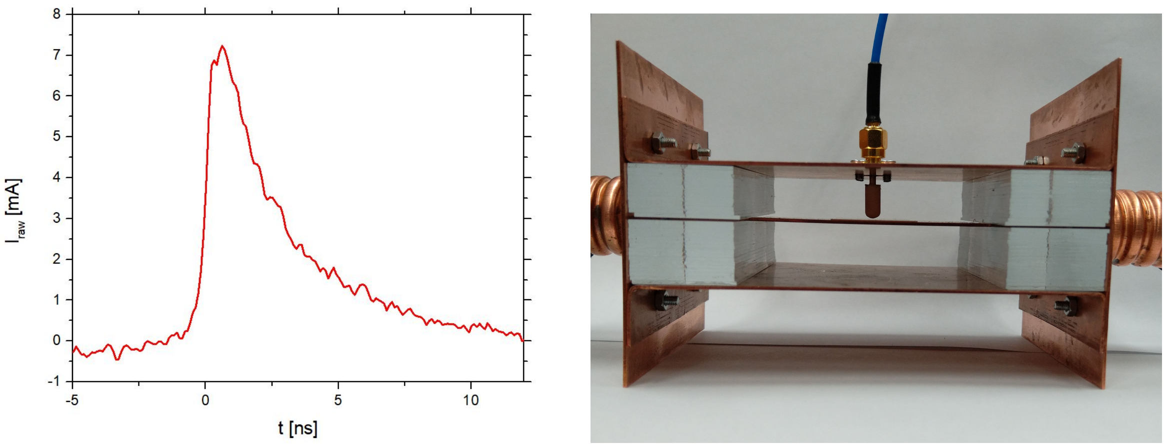

Fig. 1: An example of raw current peak profile of VDBD in ambient air captured with the 1 GHz oscilloscope LeCroy WAVERUNNER 6100 (left) and apparatus picture (right).

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