On the influence of ferroelectric materials in a packed-bed DBD reactor

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This work reports a study of atmospheric pressure barrier plasmas using ferroelectric materials as packed-bed barrier instead of classical dielectrics. Electrical characterization of the discharge shows higher values of the current that increases non-linearly with the applied voltage when ferroelectrics are used. It contributes to enhance the efficiency of plasma-gas processes taking place in this kind of reactors.

Due to their outstanding properties, such as high electrical permittivity, piezoelectricity or pyroelectricity responses, applications of ferroelectric materials are spreading across different research areas. Recently, several authors have claimed the revolutionary character of ferroelectrics for future disruptive technologies, for instance in memory storage devices, transistors or surface acoustic wave applications [1]. In the field of plasmas, ferroelectrics have been integrated in plasma actuators [2] or as barrier materials in packed-bed discharge reactors, where it was found that they contribute to enhance the process performance in different plasma gas reactions [3, 4].

Trying to shed some light into the role of ferroelectrics to promote certain chemical reactions in atmospheric pressure plasma reactors, in this work we investigate the electrical behaviour of a parallel plate packed bed barrier discharge moderated by ferroelectrics instead of classical dielectric materials. Figure 1 shows a scheme of the reactor used. It consists of two parallel electrodes separated by a packed-bed barrier, which could be constituted by barium titanate ($BaTiO_3$) or lead zirconate titanate (PZT) pellets, both ferroelectrics, or by common dielectrics, as alumina or quartz. Several experiments were performed to compare the electrical response of the reactor filled with each one of these materials by varying both voltage and frequency, either in the absence or in the presence of plasma. The current through the plasma and the impedance of the whole system were analysed, and temperature was varied to check the performance of the ferroelectrics close to the Curie point. All measurements were carried out at atmospheric pressure.

Results showed a higher current when ferroelectrics were used, being the effect noticeable on both the frequency and the voltage domains. Furthermore, when increasing the voltage, measured current followed a strong non-linear response, which can be explained in terms of the dependence of ferroelectric permittivity with the voltage. These finding are used to explain the enhanced efficiency reported in ferroelectric packed-bed reactors operated under atmospheric pressure conditions.

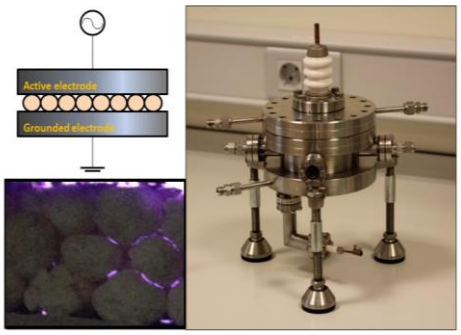

Figure 1. Scheme of the DBD reactor.

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