Characterization of a ferro-electric packed bed plasma reactor

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The influence of diverse experimental parameters on characteristics of ferro-electric packed-bed plasma reactor used for hydrogen generation was investigated experimentally. The plasma reactor consisted in two parallel circular metal electrodes (Aluminum), and spherical shaped ferro-electric pellets packed in the discharge area. Barium Titanate ($BaTiO_3$) and (Lead Zirconate Titanate, $Pb[Zr_xTi_{1-x}]O_3$ ($0 \leq x \leq 1$)) PZT was used as ferro-electric materials. Sinusoidal high voltage up to a maximum of 2.5 kV was applied to the upper electrode with a frequency range between 50Hz and 10kHz. The determination of electrical parameters (such as instantaneous power, transferred charge, breakdown voltage, electron density and capacitance properties) was carried out in different reactor configurations.

1. Introduction

The use of atmospheric non-thermal plasmas can be considered as a mature technology in several applications, such as to remove hazardous compounds or to produce valuable chemicals using the energy transfer by energetic electrons. The introduction of ferroelectrics materials into the discharge zone of the non-thermal plasma reactor is a promising way to improve their performance [1, 2]. The plasma parameters of this ferro-electric packed bed reactor are not well understood in spite of the widely applications of this type of reactors. One important property of the ferro-electric packed bed is the locally enhanced electric field inside the dielectric material (pellets and voids), near the contact points between the pellets and pellets/electrodes [3]. The use of this ferroelectric pellets as dielectric material simply reflects that ferroelectrics have spontaneous polarization below the ordering temperature. A small electric field suffices to create large polarization. In a linear response regime that means the susceptibility of the material is very high. By using typical voltage-current characteristic was experimentally monitoring the plasma reactor. These electrical magnitudes present a highly non-linear behavior that conditions the value of the different experimental parameters analyzed.

2. Experimental

Different gas mixtures of CH_4/CO_2, CH_4/O_2, CH_4/H_2O and Air, were introduced in the ferro-electric packed bed plasma reactor. Due to the dielectric (ferroelectric) barriers the reactor has capacitive properties that may be explained with the well know Q-V plot [4]. Analyzing the curvature of the Q-V Lissajous figures, the capacitance of the cell and dielectric barrier can be obtained. The ferroelectric character of the dielectric make that its capacitance be dependent of temperature and applied voltage. From these values an estimation of the breakdown voltage was evaluated and an analysis of the dissipated power from the Q-V Lissajous diagram. The calculation of the electron density relies on the assumption of a collisional regimen, in which the current density depends on the electron density and mobility and the magnitude of the electric field [5]. In order to get an accurate value for the electron density, the fact that the discharge area is not the whole surface of the active electrode has been taken into account.

3. References

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