DEVELOPMENT OF A MICROCONTROLLER-BASED PHASE RESOLVED PARTIAL DISCHARGE MEASUREMENT SYSTEM WITH APPLICATION TO THE MONITORING OF FLASH SINTERING DISCHARGE PATTERNS

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The context of this research is the development of a tool that can help understand the mechanisms of the incubation period in flash sintering carried out under high electric fields. It has been recently shown that the measurement of partial discharge (PD) patterns is a useful method to monitor the flash sintering procedure itself [1]: the partial discharge patterns change and grow under increasing electric voltage and, in particular, exhibit a significant evolution when approaching the start of thermal runaway in flash sintering. The goal of this work is to develop a bespoke, portable phase resolved partial discharge (PRPD) measurement system based on microcontroller technology in order to monitor the partial discharge activity during the application of increasing electrical voltage to a sample that is to be sintered. The system developed in this work has been shown to be able to measure partial discharge pulses from 10 pC to 1000 pC, with a repetition rate of up to 200 kS/s from 100 pC to 1000 pC and a reduced repetition rate under 100 pC. Phase-amplitude-occurrence (φ-*Q*-*n*) discharge patterns may be generated with a phase resolution of up to 1°. Our measurement device was tested on the experimental setup shown in Fig. 1 aimed at the study of room temperature flash sintering of porous zinc oxide. The cylindrical samples (diameter = 8 mm, height = 3-3.5 mm) are sandwiched between platinum electrodes connected to both an AC 50 Hz high voltage source and to the PRPD measurement system through a coupling capacitor. The electronics first separate the signal originating from the sample into a low-frequency synchronization signal and a high-frequency partial discharge signal and shape it for easier measurement and repeatability. The signal is then acquired using the microcontroller-embedded analog-to-digital converter and processed numerically in order to identify voltage pulses corresponding to partial discharge events. When applied to the measurement of PRPD patterns arising in a ZnO sample subjected to voltages from 500 to 2000V at room temperature, the system developed is shown to be able to acquire the characteristic patterns displayed in Fig. 2. Fig 2 shows the φ-*Q*-*n* pattern recorded at 1125V (E = 3571 V/cm) using the bespoke system configured with an inactivation period (dead time) of 50 µs and noise threshold of 20 pC. Fig. 3 shows the pattern recorded at 1145V (E = 3634 V/cm) on the same sample using a commercial system (ICM device from manufacturer PDIX) configured with a dead time of 5 µs and a noise threshold of 10 pC. These measurements show good agreement between the systems, giving evidence that the bespoke measurement device developed in this research to be adequate for partial discharge monitoring. This study is partly supported by ERDF and the Walloon Region, in the frame of the IMAWA-FLASHINT research project (program 2014-2020). We would like to thank Laurent Boilet and Caroline Gajdowski from the CRIBC for their supply of ZnO samples.

[1] J.-F. Fagnard, C. Gajdowski, L. Boilet, F. Henrotte, C. Geuzaine, B. Vertruyen, and P.Vanderbemden "Use of partial discharge patterns to assess the quality of sample/electrode contacts in flash sintering" J. Eur. Ceram. Soc. 41 (2021): 669-683

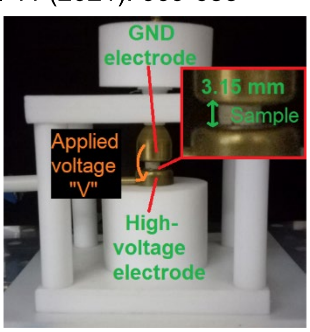

Figure 1 - Photo of the experimental setup used in this work, with zoom around sample

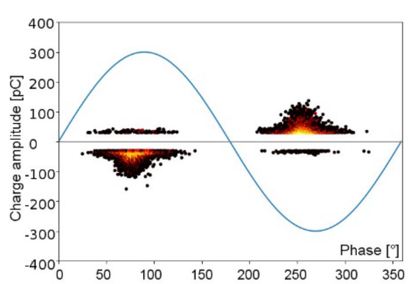

Figure 2 – Bespoke device φ-Q-n measurement (V=1125V, noise threshold=20pC)

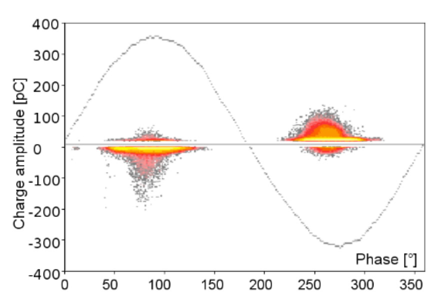

Figure 3 – ICM commercial device φ-Q-n measurement (V=1145V, noise threshold=10pC)