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Energy Consumption Characteristics of Pulsed Arc Discharge in High Pressure Carbon Dioxide up to Supercritical Phase

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Recently, a pulsed power switch using supercritical fluids has been investigated due to its high insulation strength and excellent extinguishing properties [1], [2]. The supercritical fluid switch is expected as an alternating medium of SF6. But, little is known about the energy consumption characteristics, which is unignorable effect on the efficiency of switching devices. This study deals with the medium density dependence of the consumption energy of arc discharge in pressurized carbon dioxide up to supercritical phase.
A needle-to-plane electrode with gap distance of approximately several hundred μm was set inside a high pressure chamber. The pulsed voltage was applied by a magnetic pulse compression circuit (Suematsu Elect. Co., Ltd.). The peak current of pulsed arc discharge was a few hundred Ampere in gas and supercritical phases. The consumption energy in the arc channel E was calculated by the dumped oscillatory voltage and current under the post-breakdown. In the gas phase, the E increased with medium density up to sub-critical phase. Meanwhile, the E was almost constant irrespective of medium density in the supercritical phase. Spectroscopic measurement was also carried out to confirm the local thermal equilibrium of the discharge plasma. The spectral curve was characterized by the black body radiation and line spectrums of atomic oxygen (777 and 845 nm).

[1] H. Tanoue, et al., "Dielectric recovery mechanism of pressurized carbon dioxide at liquid and supercritical phases,"Jpn. J. Appl. Phys., vol. 54, no. 9, pp. 096102-1 –096102-8, Sep. 2015.

[2] J. Zhang et al., "Breakdown strength and dielectric recovery in a high pressure supercritical nitrogen switch,"IEEE Trans. Dielectr. Electr. Insul., vol. 22, no. 4, pp. 1823 –1832, Aug. 2015.

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