Introduction of Al2O3 rods into DBD for CO2 conversion: Understanding the synergistic effect of plasma-catalysis

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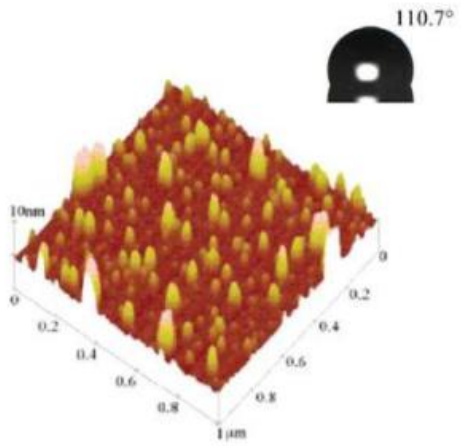
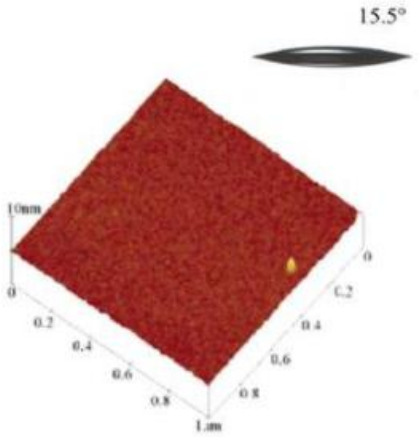
1. Introduction

Packed bed plasma reactor is a new low temperature plasma technology for material surface treatment and greenhouse gases catalytic conversion.



Before



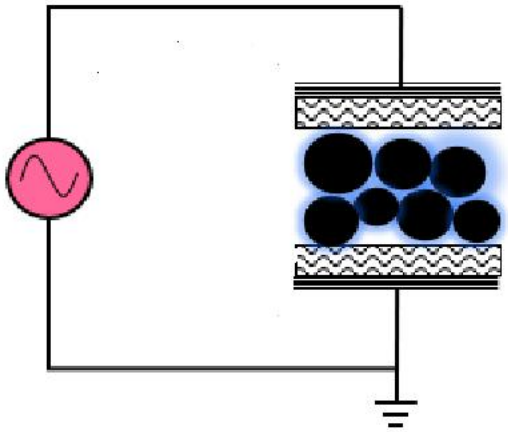
After

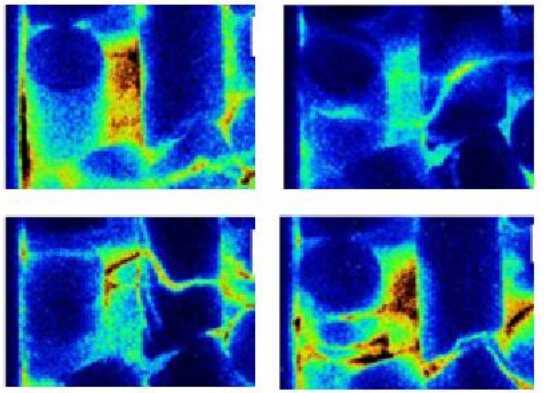
Physical and chemical properties of materials

Hydrophilic and hydrophobic properties

Catalyst reaction characteristic

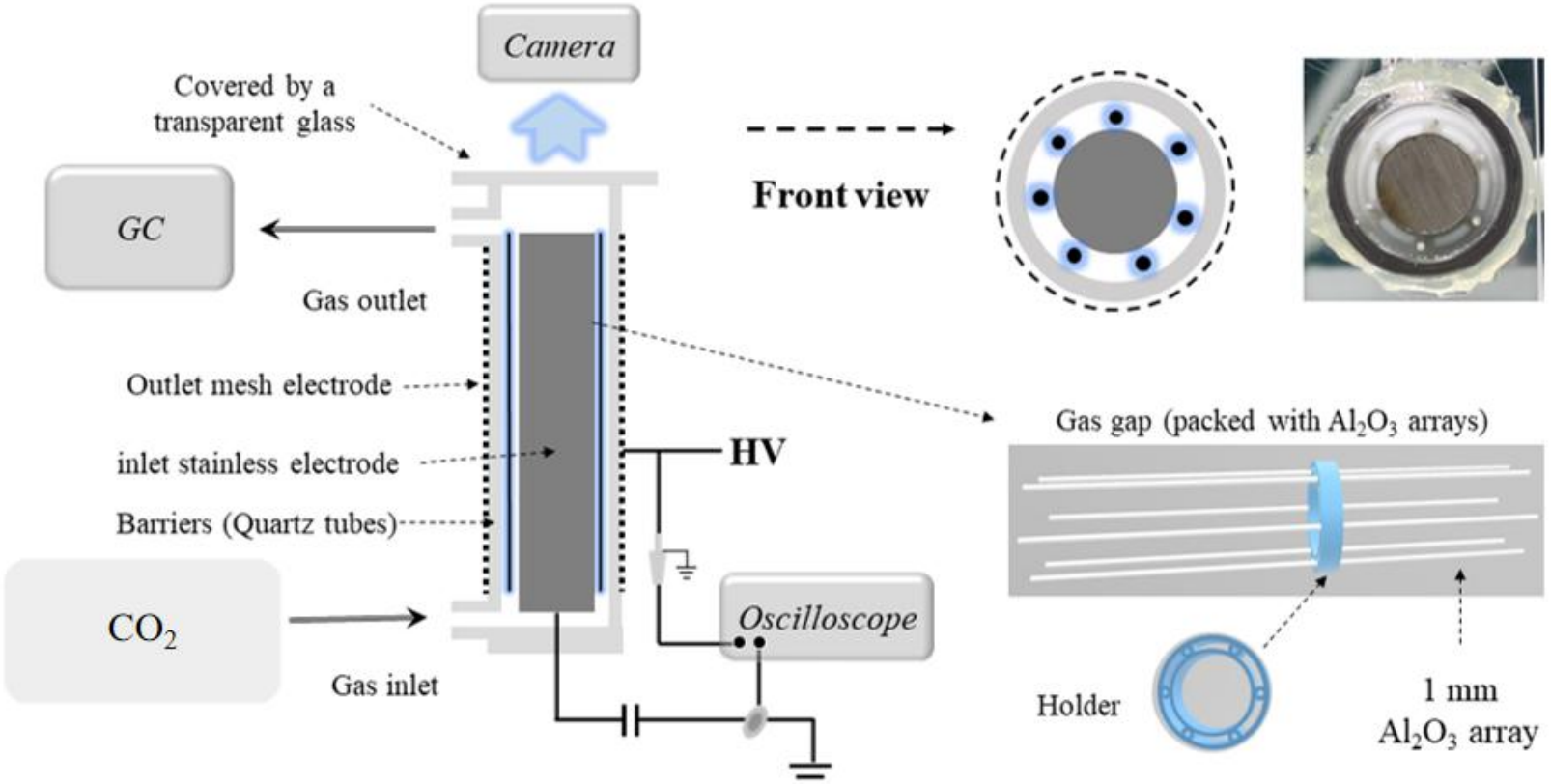
For greenhouse gases catalytic conversion, the challenge of this packed bed plasma reactor is the disordered discharge gaps among the packing materials result in complicated electrical and optical characteristics of plasma, leading to the interaction between the plasma and packing materials is not well understood.





How to regulate and control low temperature plasma in packed bed plasma reactor ??

2. Experimental Setup



Discharge gap is confined to 3 mm
Discharge volume V is limited to 11.2 ml.
CO2 is used as the feed gas and the flow rate is 20 ml min^{-1}.

Data analysis

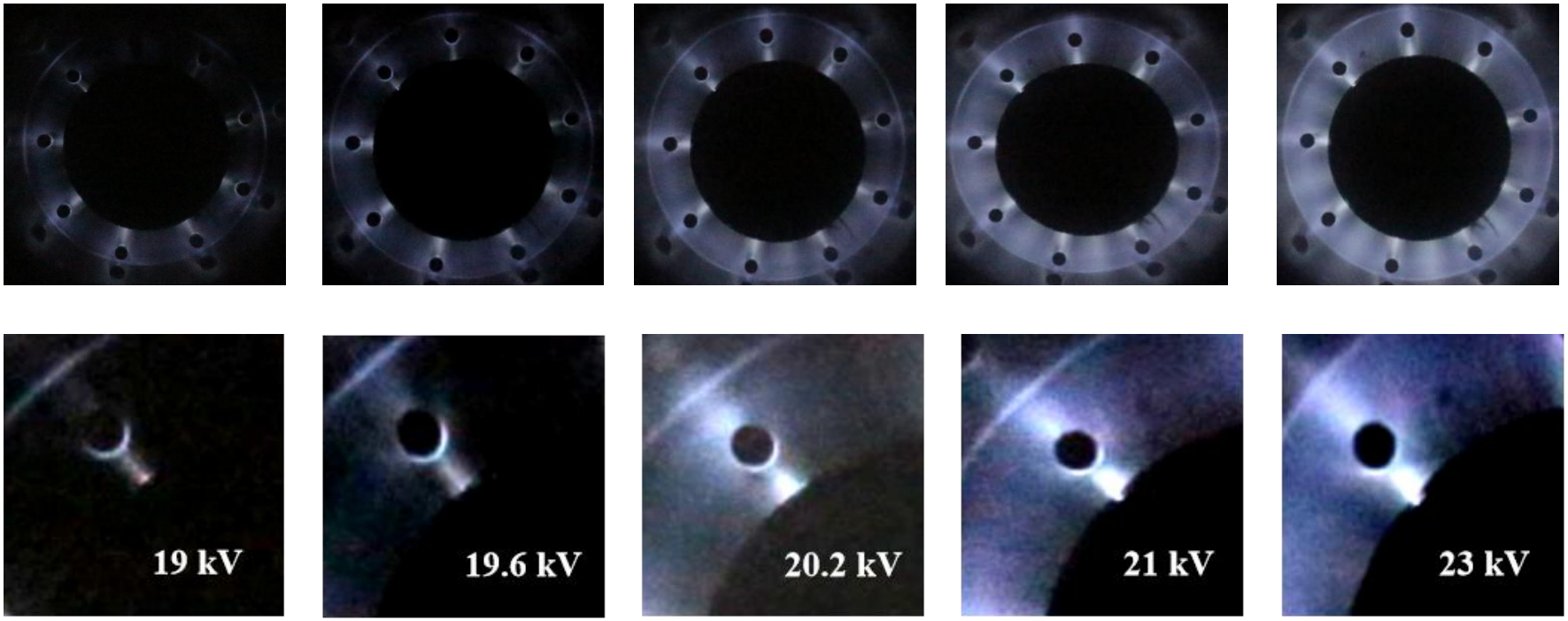
Conversion CO_2 and The energy efficiency of the plasma CO_2 conversion process (E) can be obtained with the following formulas:

$$CO_2 \text{ conversion } (\%) = \frac{CO_2 \text{ converted } (\text{mol s}^{-1})}{CO_2 \text{ input } (\text{mol s}^{-1}) \times 100}$$

$$E\,(\text{mmol kJ}^{-1}) = \frac{CO_2 \text{ converted } (\text{mol s}^{-1})}{\text{Discharge power } (\text{kW})}$$

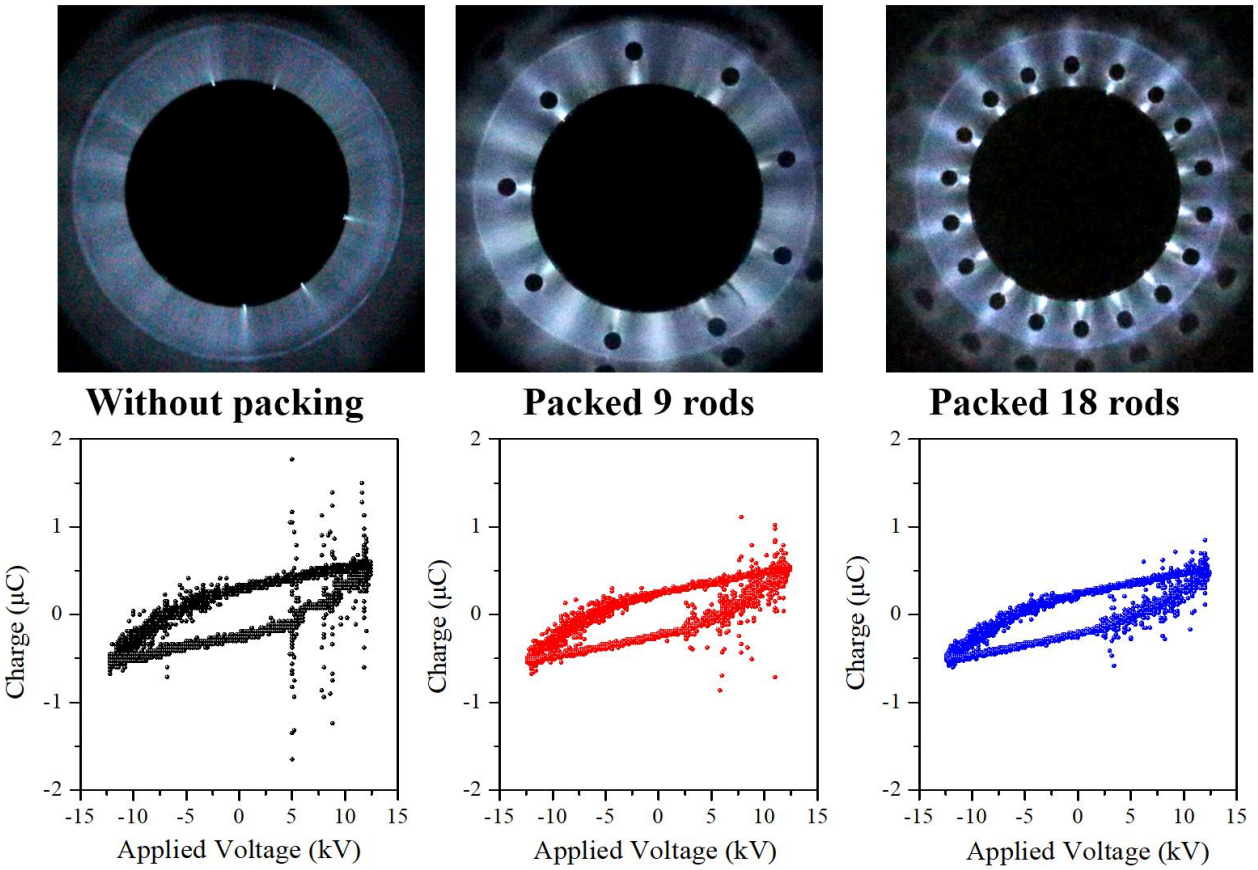
3. Results

Discharge characteristics of plasma with Al_2O_3 rods packed



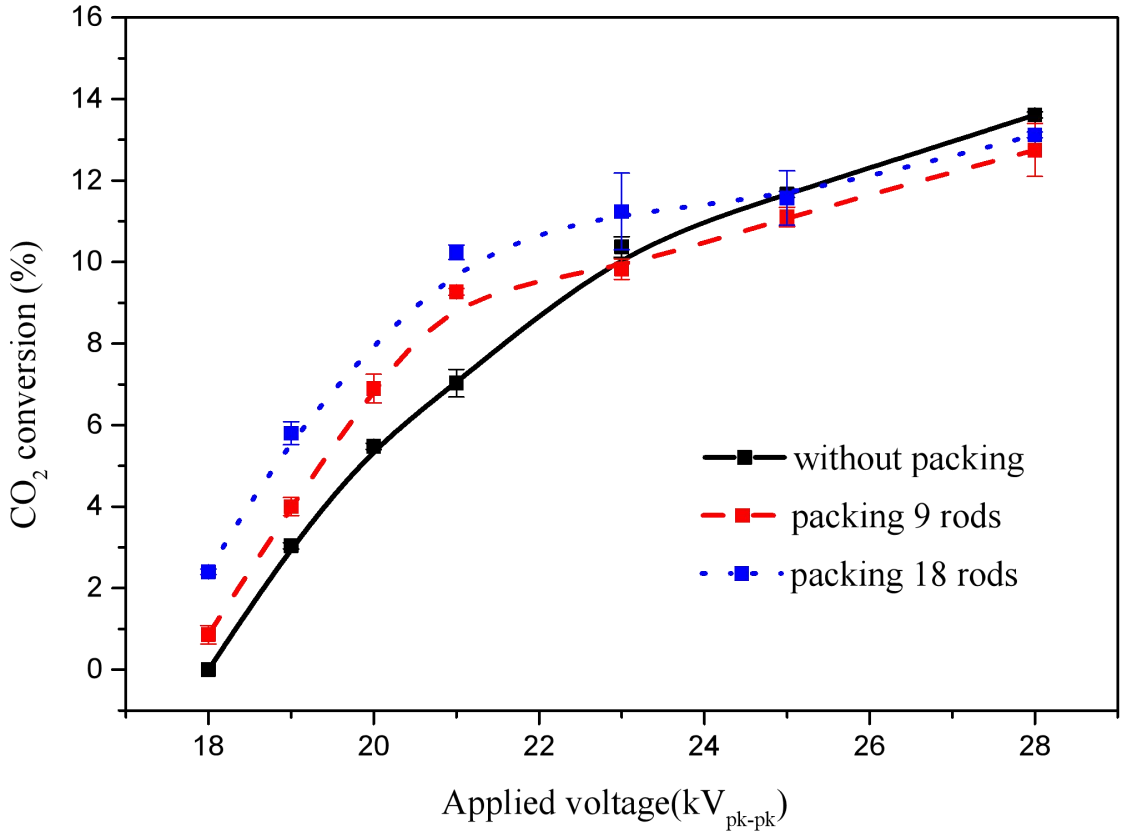
The plasma image as a function of the applied voltage.
The number of Al_2O_3 rod is 9.

Discharge characteristics of plasma with Al_2O_3 rods packed



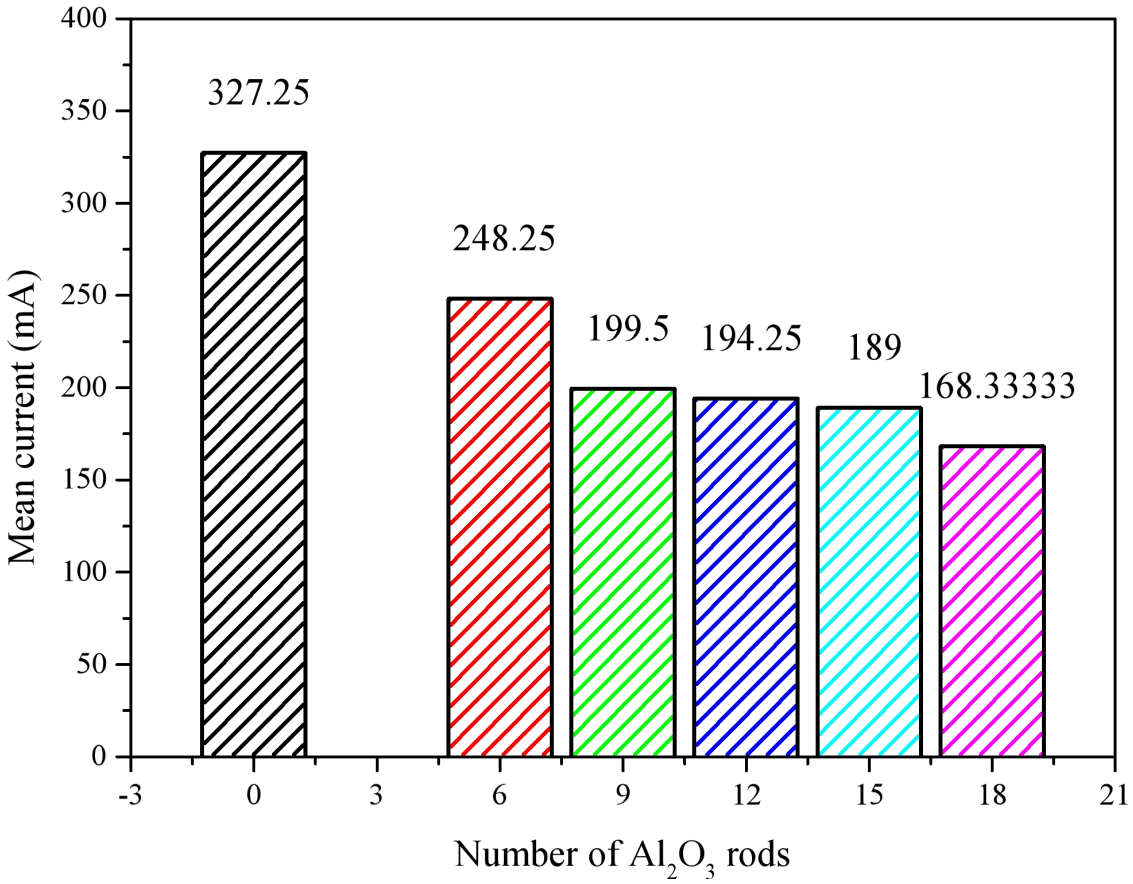
The plasma image and Q-U Lissajous figure as a function of the number of packing rods. Those different reactors have the same operating conditions. The exposure and IOS of those images are set as 0.025 s and 12800. The value of applied voltage is 25 $kV_{pk\text{-}pk}$.

Conversion efficiency of CO_2 with Al_2O_3 rods packed



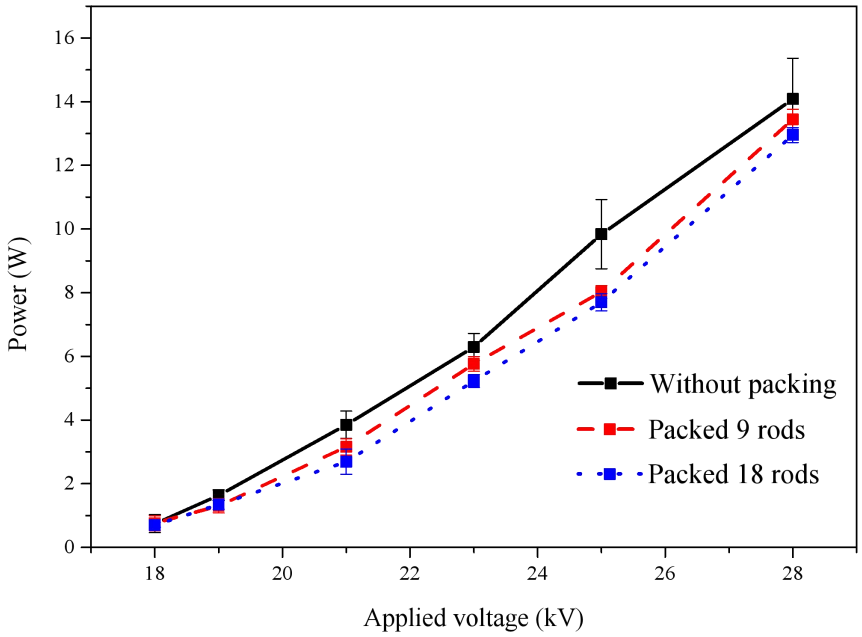
CO_2 conversion vs applied voltage for there specified DBD reactor, i.e. with no packing, packing 9 rods and packing 18 rods.

Discharge characteristics of plasma with Al_2O_3 rods packed

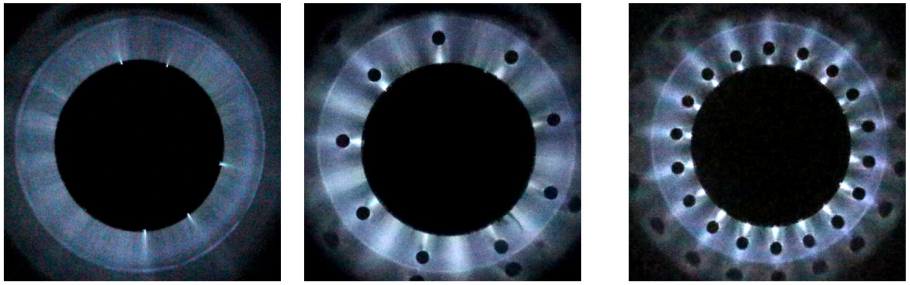


The mean discharge current as a function of the number of packing rods, when the value of applied voltage is 25 kV_{pk-pk}.

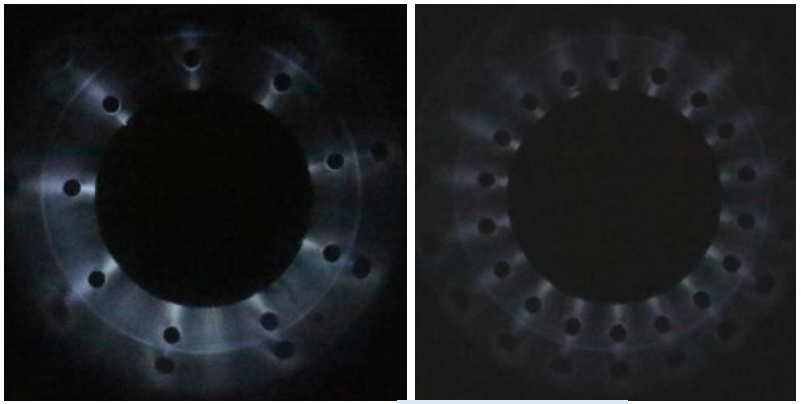
Discharge characteristics of plasma with Al_2O_3 rods packed



Plasma discharge power as a function of applied voltage and the number of packing rods



25 kV_{pk-pk}



21 kV_{pk-pk}

4. Conclusion

- with the Al_2O_3 rod packed, the region where plasma is being created is gradually reduced, and the discharge type of plasma is shifted from filamentary discharge to a combination of surface discharge and polar discharge

- The plasma discharge intensity on the surface of the material varies with the applied voltage and the number of rods.

- The reduction of plasma areas in discharge gap is main reason for the decreasing of CO_2 conversion, resulted in the part of reactive gas cannot enter the plasma, and leading to the decreasing of reaction efficiency.

Thanks for Your Attention!