# Plasma-photocatalytic conversion of $CO_2$ at low temperatures: Understanding the synergistic effect of plasma-catalysis

Danhua Mei[a], Xinbo Zhu[a], Chunfei Wu[b,c], Bryony Ashford[a], Paul T. Williams[b], Xin Tu*[a]

a. Department of Electrical Engineering and Electronics, University of Liverpool, Liverpool, L69 3GJ, UK.

b. Energy & Resource Research Institute, The University of Leeds, Leeds, LS2 9JT, UK.

c. School of Engineering, University of Hull, Hull, HU6 7RX, UK.

**Corresponding Author**

*Dr. Xin Tu

Department of Electrical Engineering and Electronics,

University of Liverpool,

Liverpool, L69 3GJ,

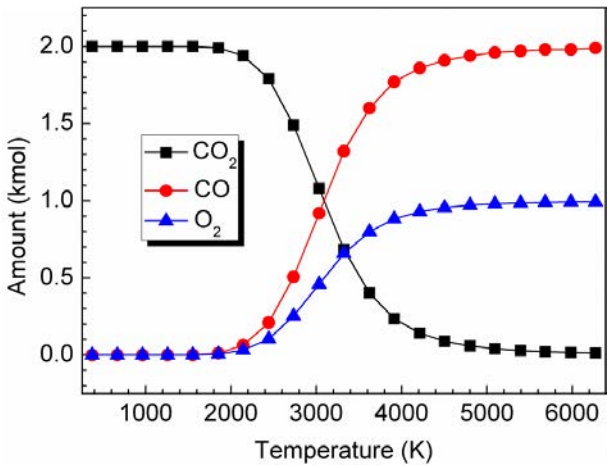
UK

Tel: +44-1517944513

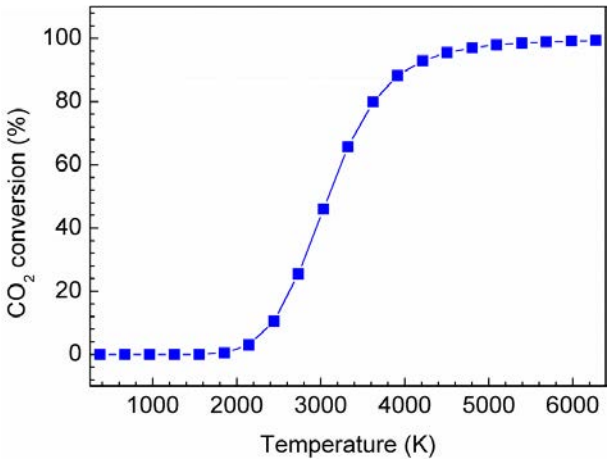
E-mail: xin.tu@liverpool.ac.uk

## 1. Thermodynamic equilibrium calculation

The thermodynamic equilibrium calculation of $CO_2$ conversion was carried out using the method based on the minimization of Gibbs free energy in a closed system. The main gas products are CO and $O_2$. No $O_3$ was detected in the present experiment. We can see that $CO_2$ begins to decompose into CO and $O_2$ near 2000 K and the conversion of $CO_2$ is very low (< 1%). Reasonable conversion of $CO_2$ (~60%) can be obtained at an extraordinarily high temperature (3000-3500K), which leads to the high energy cost for thermal conversion of $CO_2$.




(a)



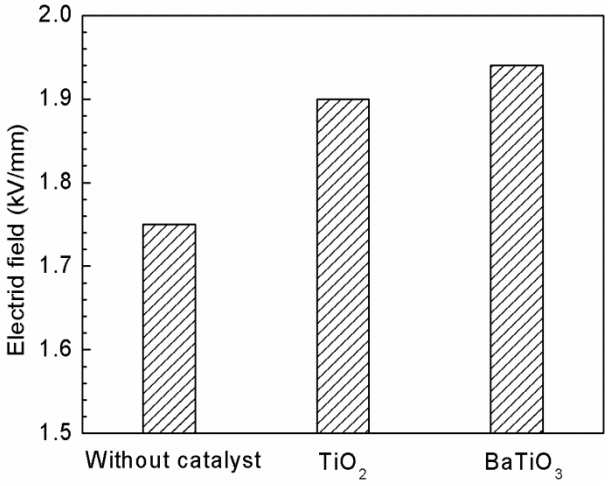

(b)

Fig. SI1 Thermodynamic equilibrium calculation of $CO_2$ conversion as a function of

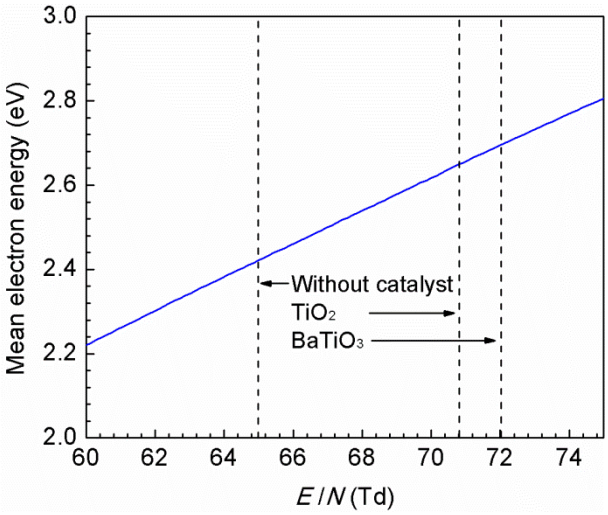
operating temperature at 1 atm (without plasma) (a) gas composition vs. temperature; (b) $CO_2$ conversion vs. temperature.

## 2. Mean Electric field and electron energy

The average electric field of the discharge (breakdown voltage/electrode gap) and the mean electron energy for the three different experimental conditions are calculated through Lissajous figure and BOLSIG$^+$ code based on electron energy distribution function (EEDF), respectively[1, 2] and the corresponding results are shown in Fig. SI2.




(a)




(b)

Fig. SI2 Averarge electric field (a) and mean electron energy (b) of the $CO_2$ DBD with and without catalyst.

## 3. Catalyst characterization

XRD patterns of the catalyst samples are plotted in Figure SI3. $BaTiO_3$ has the tetragonal phase [3], which can be approved by the peaks at $2\theta$ = 22.14°, 31.61°, 39.00°, 45.37°, 51.00°, 56.32°, 65.94° (JCPDS 05-0626), while the fresh $TiO_2$ shows a crystal structure of anatase, as evidenced by X-ray reflections at $2\theta$= 25.24°, 36.94°, 37.82°, 38.56°, 48.04°, 53.96°, 55.00°, 62.69°, 68.76° (JCPDS 84-1286)[4].

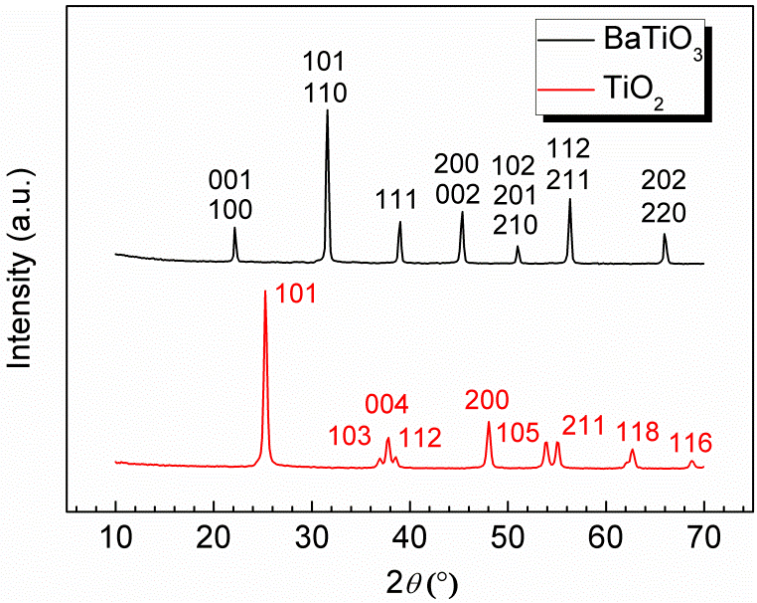



Fig. SI3 XRD patterns of the fresh catalysts.

## Reference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[4] K. Thamaphat, P. Limsuwan, B. Ngotawornchai, Kasetsart Journal : Natural Science, 42 (2008) 357-361.