

## Non-equilibrium plasma-assisted dry reforming of methane over shape-controlled CeO<sub>2</sub> supported ruthenium catalysts

Md Robayet Ahasan,<sup>1</sup> Monir Hossain,<sup>1</sup> Xiang Ding,<sup>2</sup> and Ruigang Wang<sup>1\*</sup>

\*Email: [rwang@eng.ua.edu](mailto:rwang@eng.ua.edu)

<sup>1</sup>Department of Metallurgical and Materials Engineering, The University of Alabama, Tuscaloosa, AL 35487, United States

<sup>2</sup>College of Urban and Environmental Sciences, Peking University, Beijing 100871, China

**Table S1 H<sub>2</sub> consumption, and reduction temperature of the prepared samples and their crystalline size from the XRD and H<sub>2</sub>-TPR profiles.**

Sample	Crystal size (nm)	BET surface area (m <sup>2</sup> /g)	H <sub>2</sub> Consumption (mmol/g)		Total	Peak temperature (°C)		
			O <sub>s</sub> peak	O <sub>b</sub> peak		α	β	γ
1 wt% Ru/ SiO <sub>2</sub> -o	14.8	198.2	5.32	25.54	30.86	146	N/A	517
1 wt% Ru/ SiO <sub>2</sub> -r	10.5	255.7	1.01	27.53	28.54	57	N/A	532
1 wt% Ru/ CeO <sub>2</sub> NR-o	7.0	73.9	27.93	1.96	29.89	105	129	731
1 wt% Ru/ CeO <sub>2</sub> NR-r	7.2	100.3	22.39	7.74	30.13	82	343	753
1 wt% Ru/ CeO <sub>2</sub> NC-o	19.8	41.2	28.17	1.72	29.89	115	158	721
1 wt% Ru/ CeO <sub>2</sub> NC-r	19.9	54.9	8.92	20.46	29.38	67	265	743

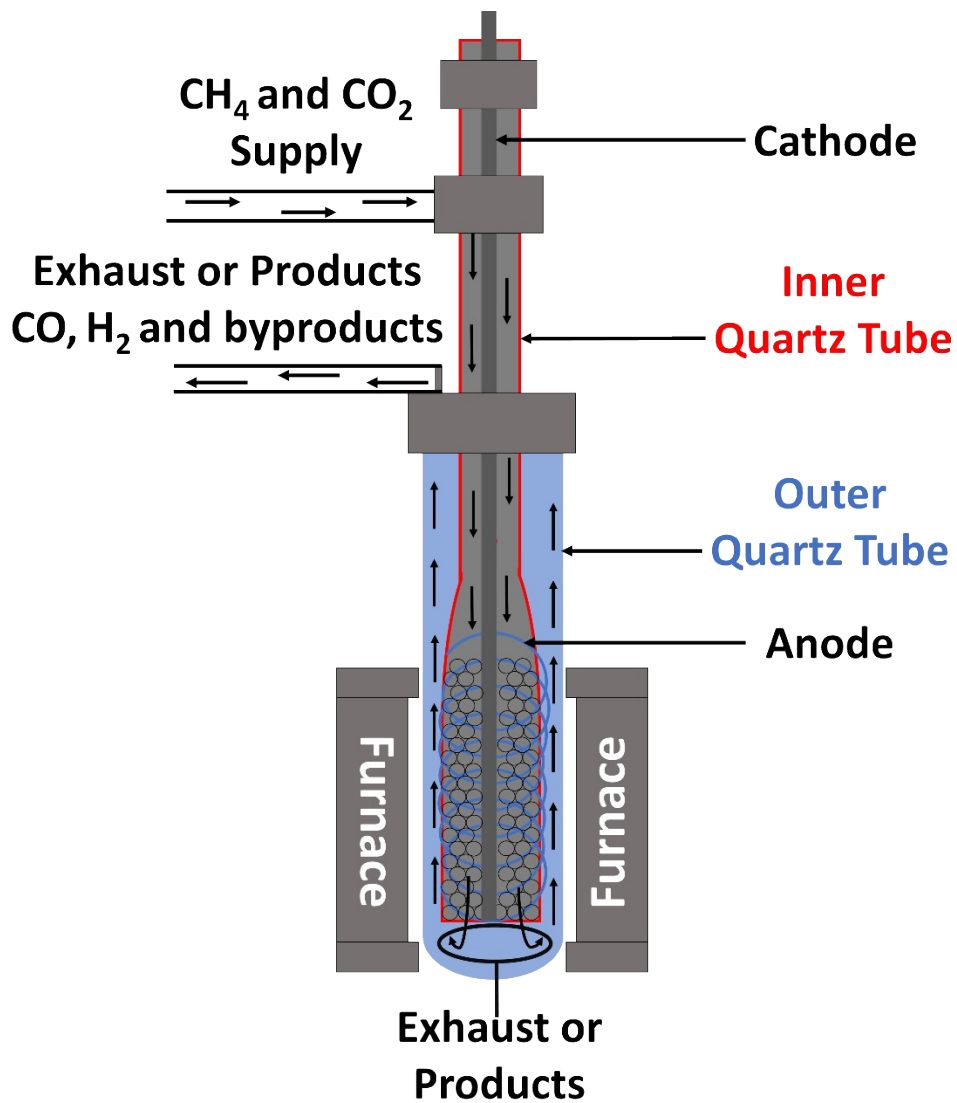
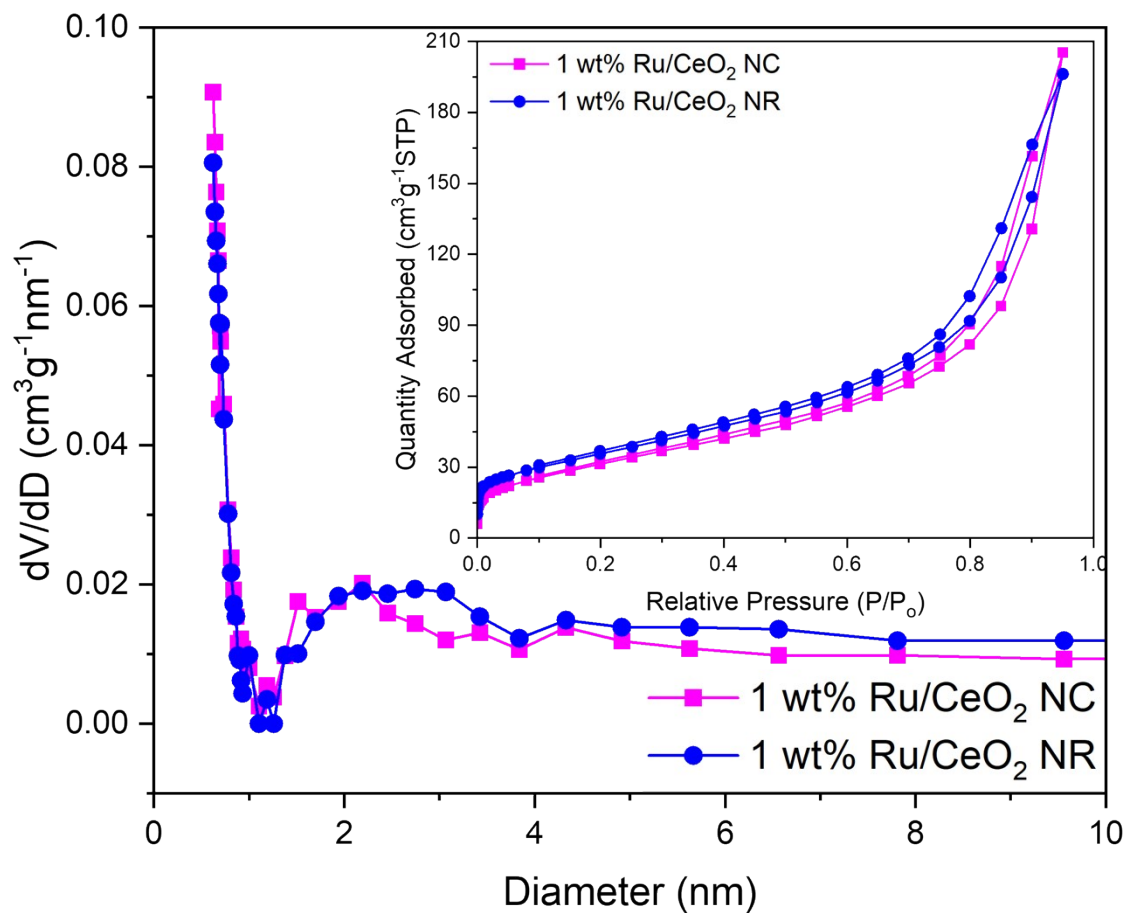
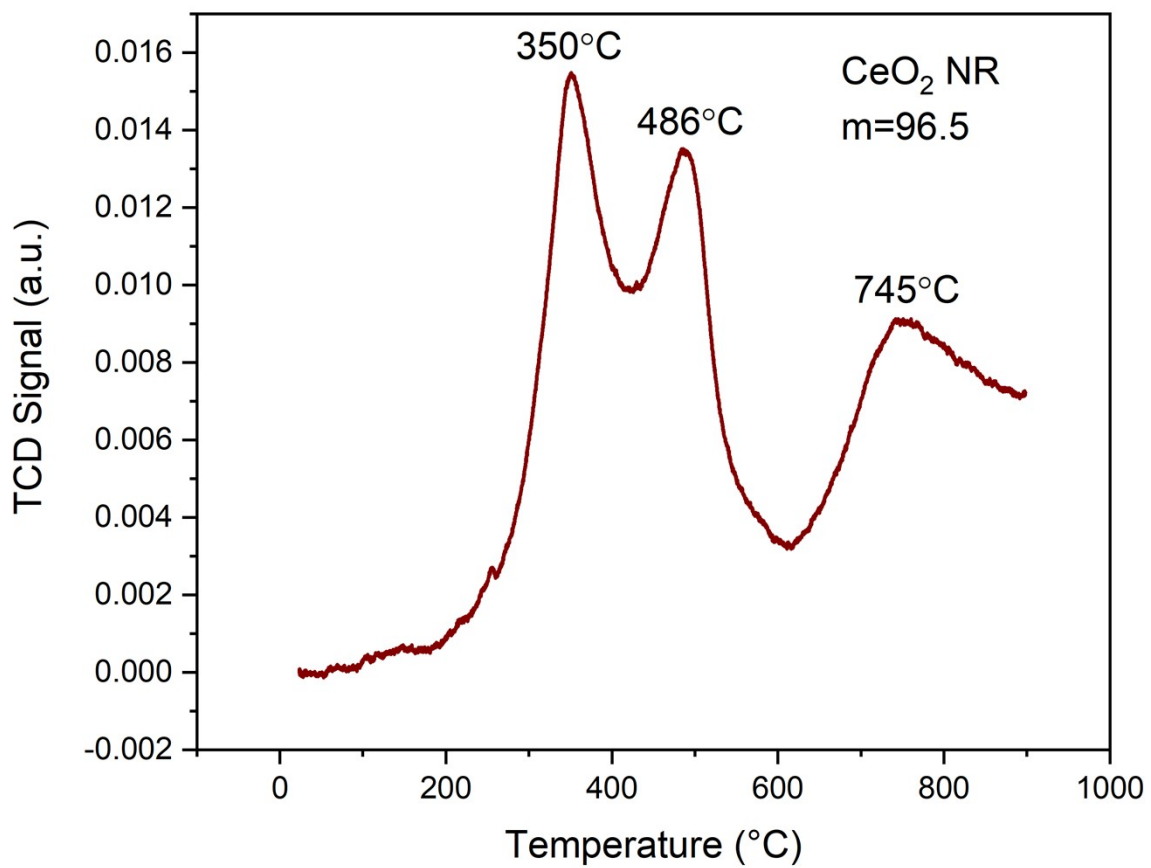


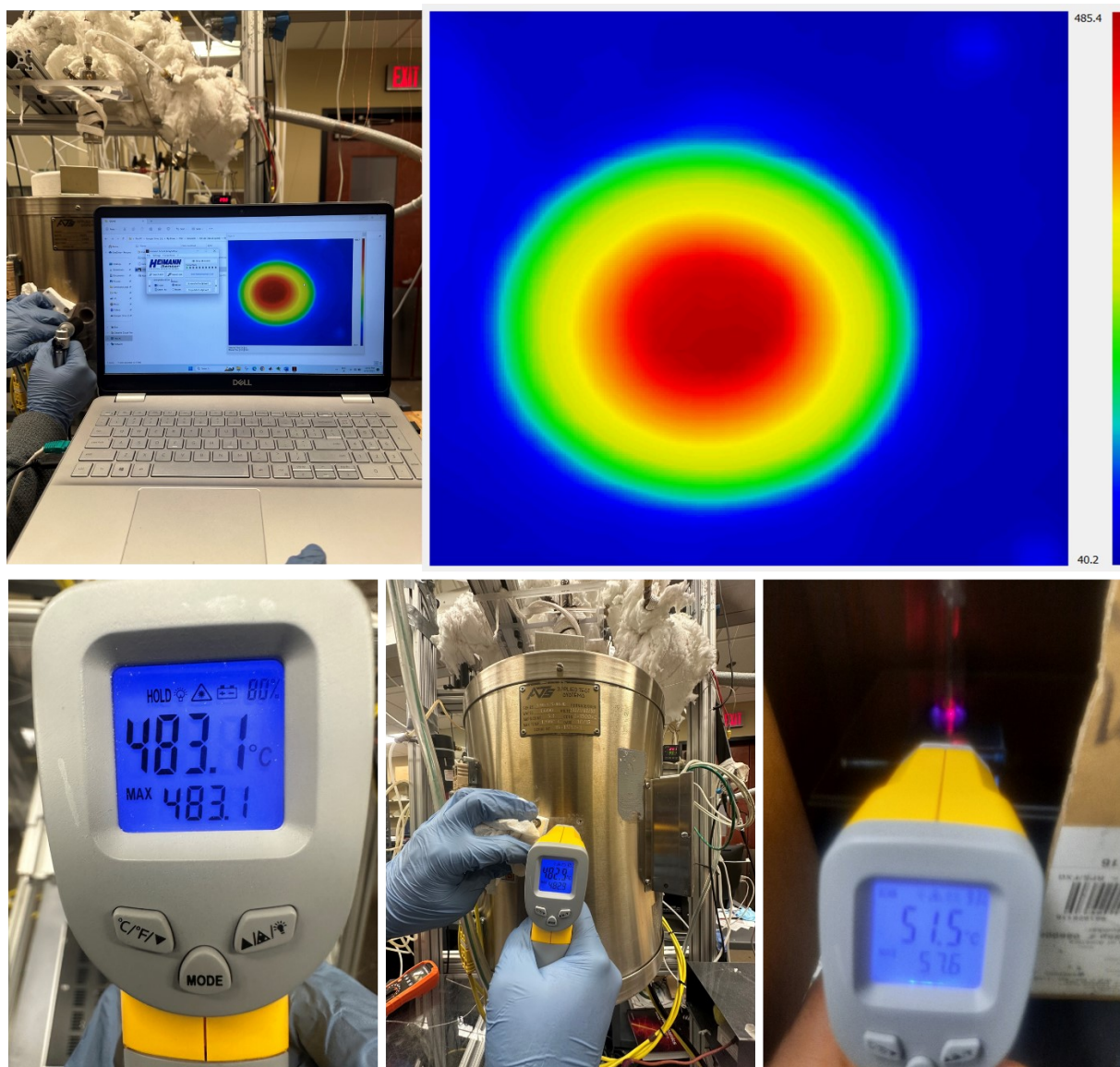
Fig. S1 Zoomed figure of the central part of DBD reactor.



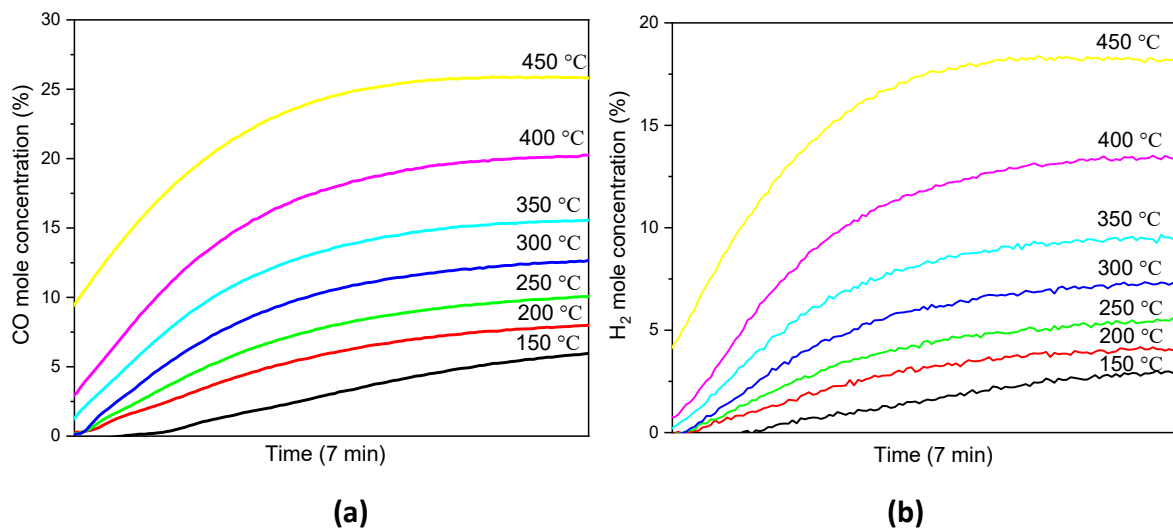
**Fig. S2** N<sub>2</sub> adsorption/desorption and pore size distribution of 1 wt% Ru/CeO<sub>2</sub> NC and 1 wt% Ru/CeO<sub>2</sub> NR catalysts.



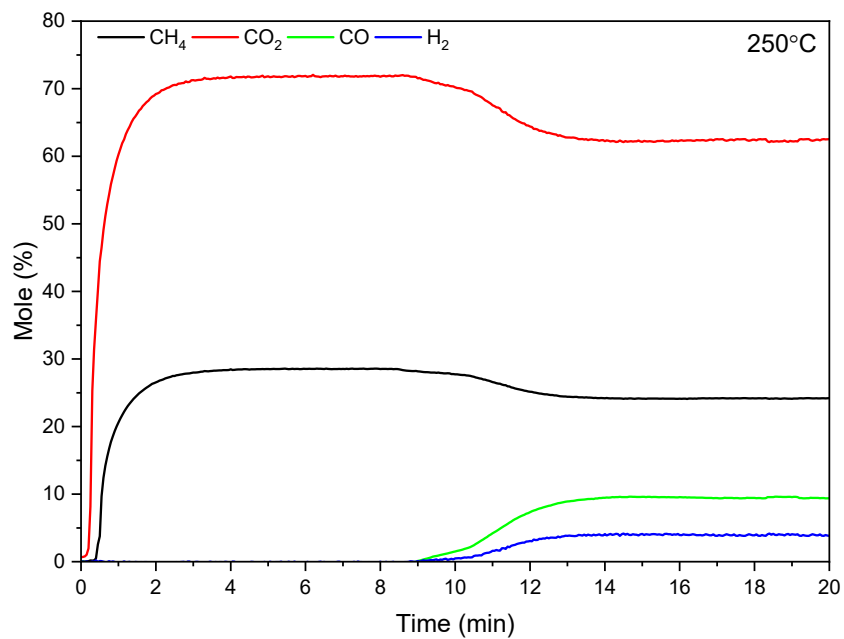
**Fig. S3 H<sub>2</sub>-TPR profiles of CeO<sub>2</sub> NR.**



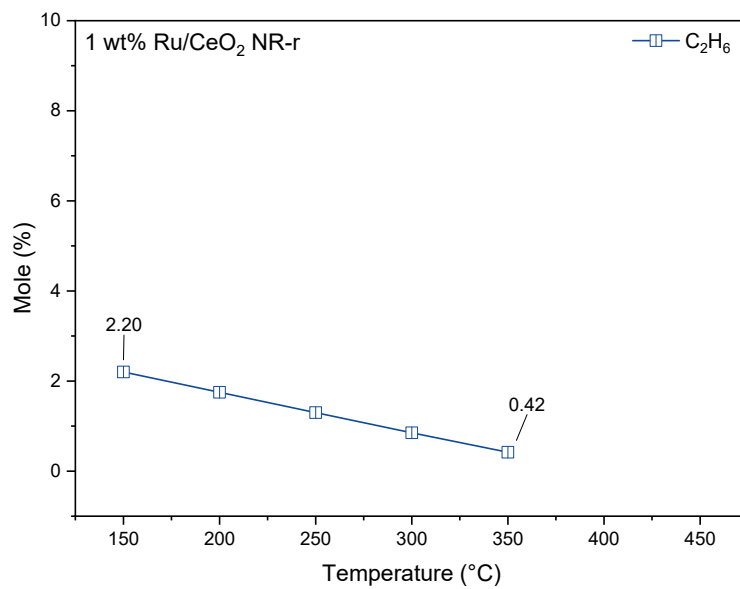
**Fig. S4 Measurement of temperature at plasma catalytic reaction zone with thermopile infrared array sensor and infrared thermometer.**



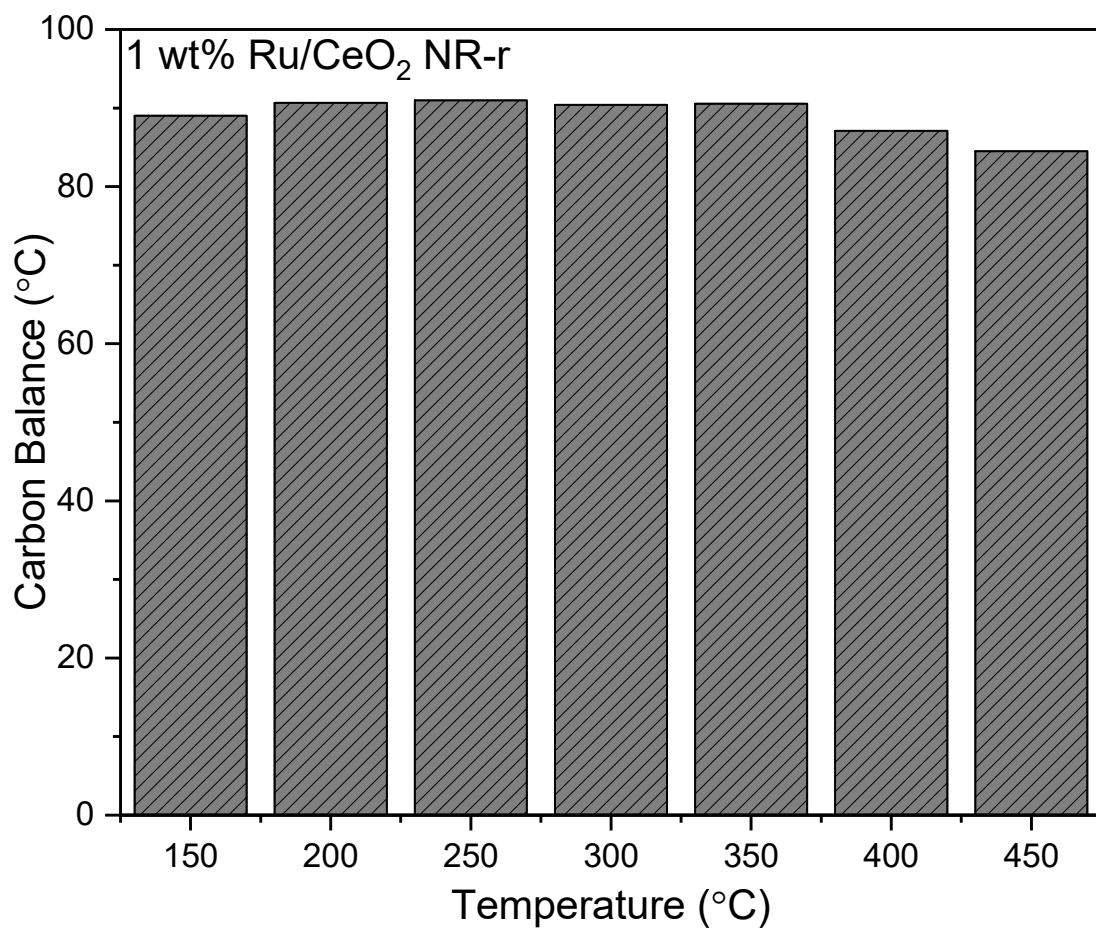
**Fig. S5 CO (a) and H<sub>2</sub> (b) molar concentration with time at temperature from 150 °C to 450 °C by the 1 wt% Ru/CeO<sub>2</sub> NR-r catalyst in plasma assisted DRM reaction.**



**Fig. S6** Variation of gas species concentration with reaction time at 250 °C for 1 wt% Ru/CeO<sub>2</sub> NR-r catalyst.

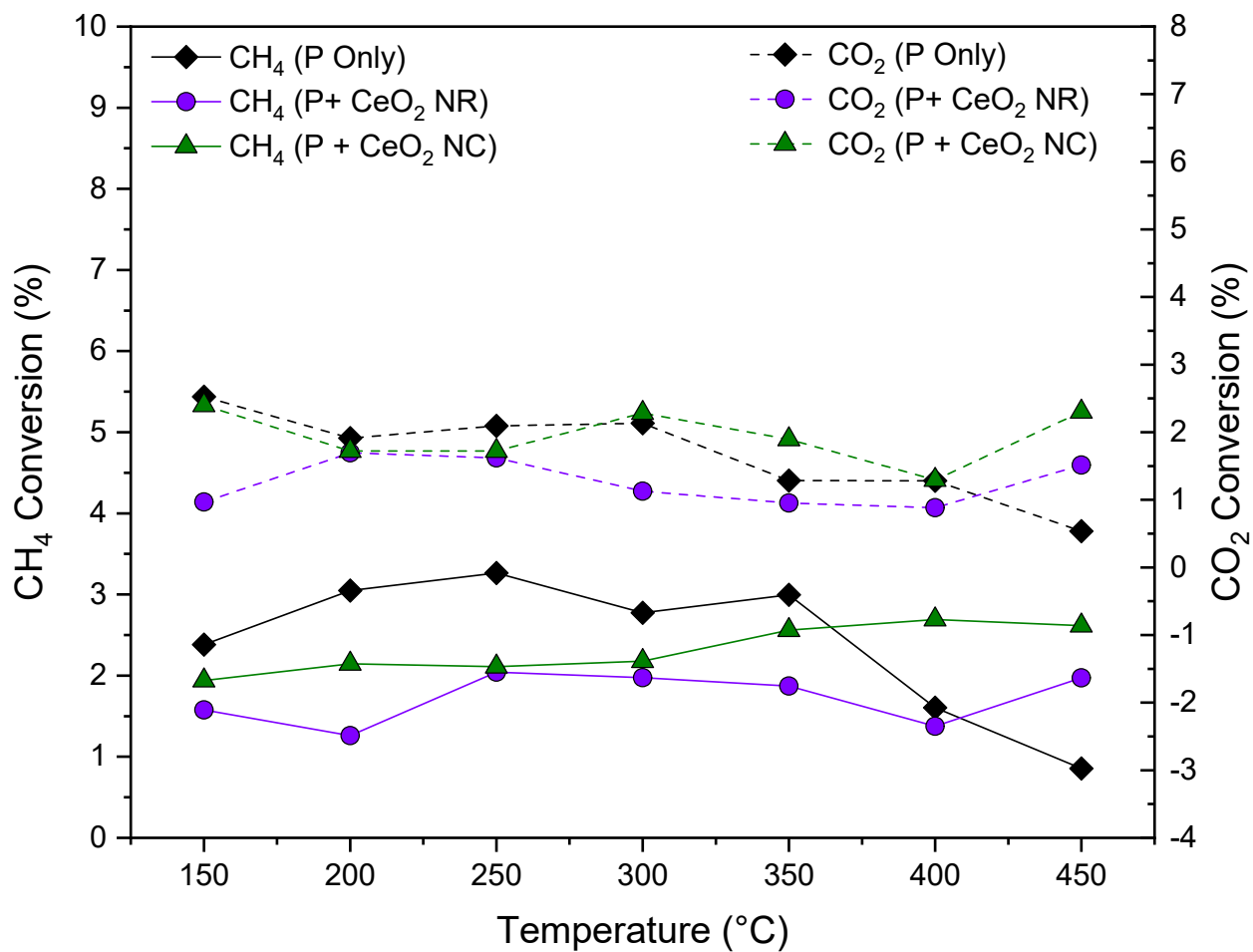


**Fig. S7** C<sub>2</sub>H<sub>6</sub> formation by 1 wt% Ru/CeO<sub>2</sub> NR-r catalyst in plasma assisted DRM reaction.

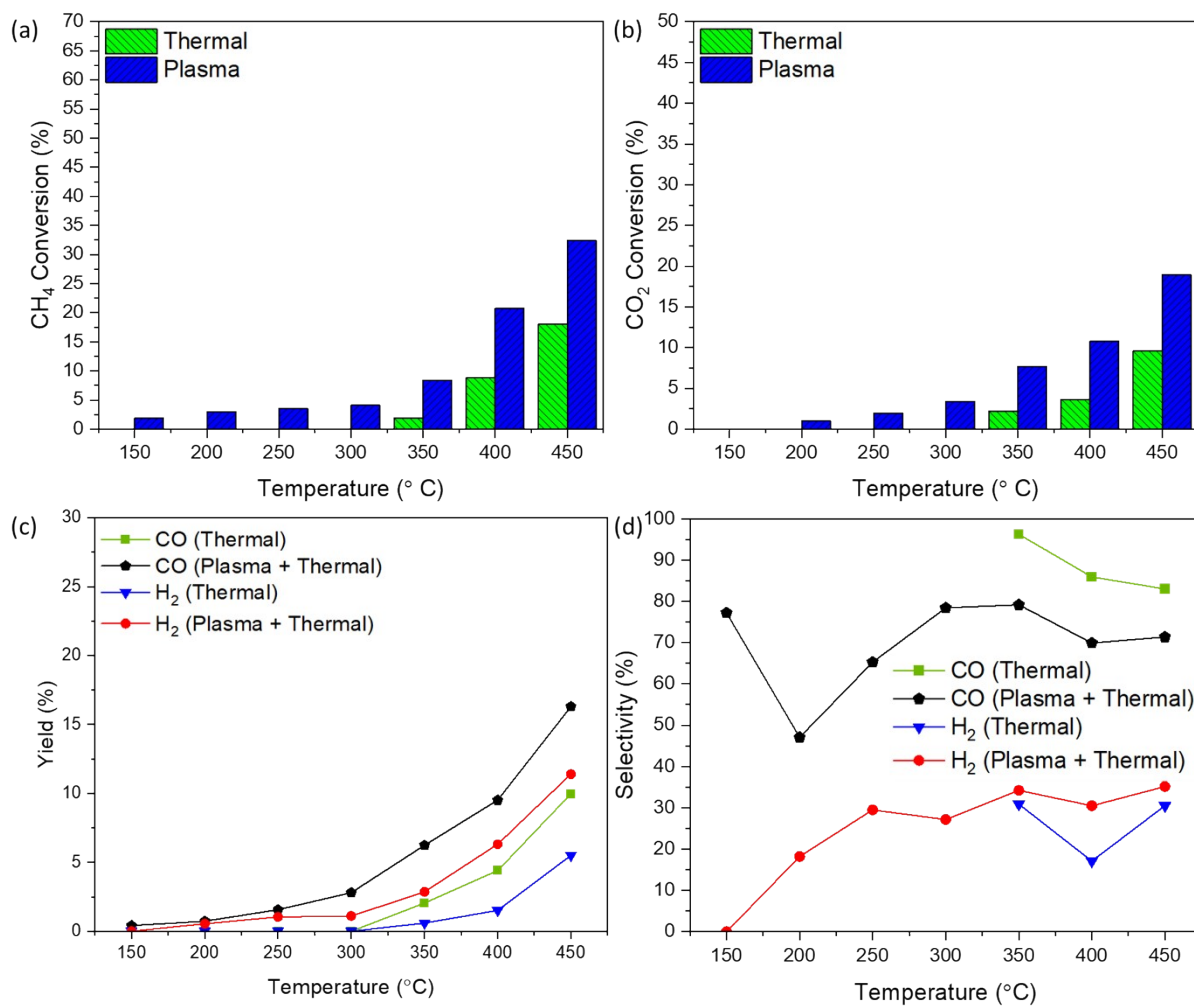


**Fig. S8 Carbon balance of 1 wt% Ru/CeO<sub>2</sub> NR-r.**

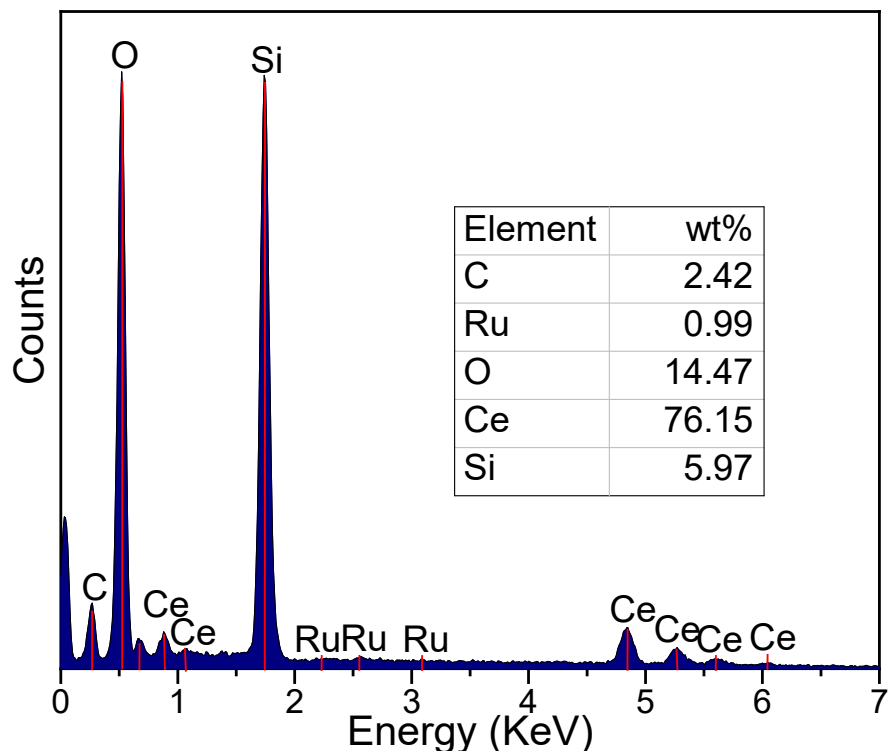




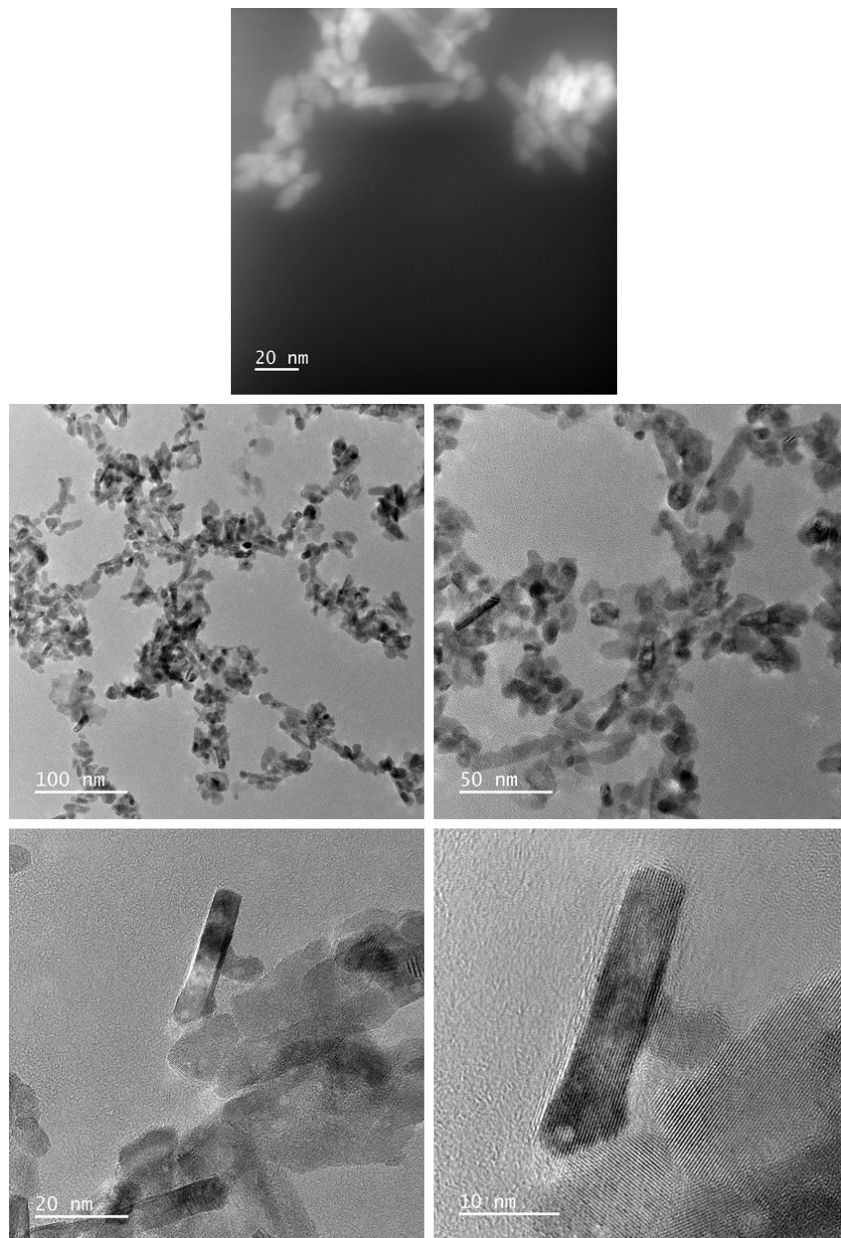
**Fig. S9 CH<sub>4</sub> and CO<sub>2</sub> conversion of only plasma (without catalysts) and plasma + bare CeO<sub>2</sub> NP from 150 °C to 450 °C. (Catalyst wt.: ~200 mg, Power: 10.2 to 13.6 W, Flowrate: CO<sub>2</sub>: 250 sccm and CH<sub>4</sub>: 100 sccm).**



**Fig. S10 (a) CH<sub>4</sub> and (b) CO<sub>2</sub> conversion of 1 wt% Ru/SiO<sub>2</sub> NC; (c) CO and H<sub>2</sub> Yield and (d) selectivity of 1 wt% Ru/SiO<sub>2</sub> from 150 °C to 450 °C under thermal and thermal + plasma conditions. (Catalyst weight: ~200 mg; power: 10.2 to 13.6 W; frequency: 20 kHz; flowrate: CO<sub>2</sub>: 250 sccm and CH<sub>4</sub>: 100 sccm).**



**Fig. S11 EDX profile of used 1 wt% Ru/CeO<sub>2</sub> NR-r catalyst.**



**Fig. S12 STEM and HRTEM images of the spent 1 wt% Ru/CeO<sub>2</sub> NR-r catalyst.**