開發高效能次奈米異質原子团塊於二氧化碳光電轉換與神經修復調控之應用

Hierarchical sub-nanometer hetero-atomic clusters for photoelectronic conversion of CO_2 and nerve repair.

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The atomic clusters contain a discrete density of state and a sharp geometric configuration. Both the two scenarios reduce the binding energy therefore facilitating the electron injection to the adjacent chemical species. By taking these advantages, the atomic cluster decorated NCs are faceable for the specific applications which require a high density of electron in local regions. With these understandings, we developed oxide supported metallic NCs with atomic cluster decoration for the photoelectronic conversion of CO_2 and nerve repair. The NCs with proposed hierarchical structures are applied to the oxygen reduction reaction (ORR) with a current density of 2,000 mA mg^{-1} @ 0.85 V vs. RHE for 300 k potential cycles (operation for 10 months). In a subsequent experiment, the local atomic defect of NCs is recovered by exposing to mini-second laser annealing and the corresponding CO_2 conversion efficient is improved by 30%. The atomic cluster decorated NC provides effective electric filed that improve the neuron dendrite elongation by more than 200% as compared to that in the control experiment. Details for the results in the corresponding scenarios (**Figure 1**) are addressed in below.

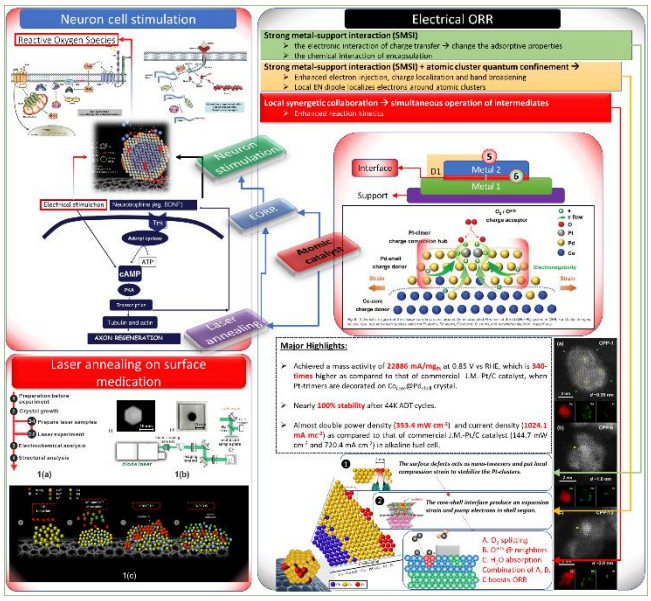

Figure 1 The proposed application of atomic cluster decorated NCs and the corresponding correlations.

In ORR, the NCs is a Co oxide supported Pd nanocrystal with trimetallic Pt cluster decoration. The current density is two orders higher than that of commercial Pt catalysts in the same noble metal loading and corresponding results is published and been selected as the featured article in energy materials of the Nature Communication in Feb. 2019. ((2019) 10:440 | https://doi.org/10.1038/s41467-019-08323-w) and the author (Tsan-Yao Chen) had been

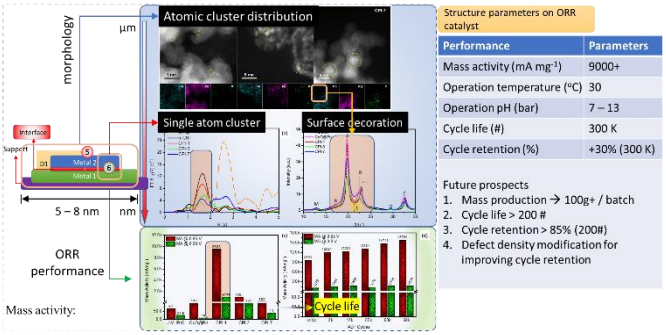

Figure 2 The single Ir atom oxide decorated Co@Pd NC and is corresponding ORR performance.

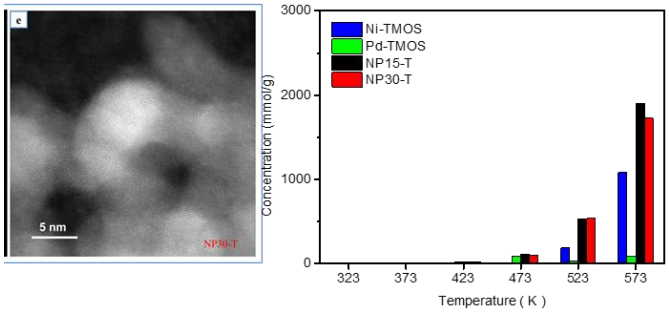

Figure 3 The metal oxide supported NCs and the corresponding CO production yield in CO_2RR.

selected as highlighted scientist in the special issue of "Spotlight on Taiwan 2020" in Nature. By reducing the cluster size to single atoms, the ORR performance of NC is further improved by folds and corresponding results are demonstrated in Figure 2. The samples of metal oxide supported Pd catalysts is adopted to CO_2 conversion which reach a record high CO production yield (3,000 mmol / mg) among existing NCs with the sample composition in a mixture of H_2 and CO_2 ambient at 200°C (Figure 2). By adopting sub-nm NCs in electric stimulation, the dendrite of neuron cell can be elongated to more than 20 μm in 120 hr and is 2-folds improved as compared to that of control experiment. With proper adjustment on the frequency of applied potential, the nerve conduction matters can be effectively transferred to facilitate the cell dendrite growth (**Figure 3**).

Sub-mini-second pulse laser annealing system with a wavelength of 976 nm is developed to recover the local defects of the NCs. The size of beam-path on catalyst powder is 10 mm^2. The NCs is annealed at the operation frequency of 1 – 100 Hz with the energy density ranging from 1 – 10 mJ and the pulse duration is 850 μ s. By adopting physical structure characterizations, the recovery of local structure defects is confirmed. The output of this project is summarized in **Table 1**.

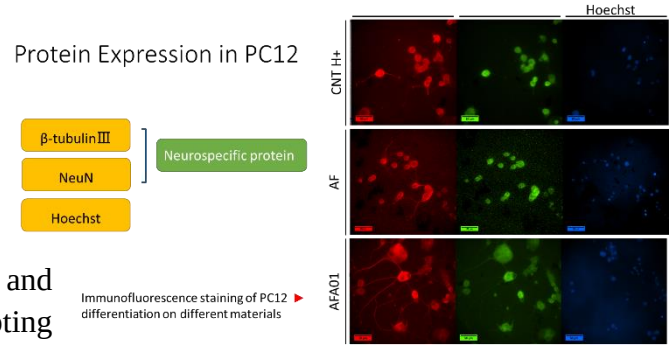

Table 1 Summary of published paper in this project

Topic	SCI paper	Conference paper	in preparation	patent
ORR	6	0	3	0
laser	1	0	0	0
ORR biomedical application	0	2	0	0

Selected References

[1] Sheng Dai, Jyh-Pin Chou, Kuan-Wen Wang, Yang-Yang Hsu, Alice Hu, Xiaoqing Pan, Tsan-Yao Chen.* "Platinum-trimer decorated cobalt-palladium core-shell nanocatalyst with promising performance for oxygen reduction reaction." Nature Communications 2019, 10 (1), 440.