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Monolithic Co_3Se_4 Nanowire Electrodes for Highly Efficient and Stable Oxygen Evolution and Overall Water Splitting

Abstract

Cobalt selenide has been proposed to be an effective low-cost electrocatalyst towards the oxygen evolution reaction (OER) due to its well-suited electronic configuration [1]. However, pure cobalt selenide has by far still exhibited catalytic activity far below what is expected. In this presentation, we for the first time report the synthesis of a new phase of monoclinic Co_3Se_4 thin nanowires on cobalt foam (CF) via a facile one-pot hydrothermal process using selenourea [2]. When used to catalyze OER in basic solution, the monolithic self-supported Co_3Se_4/CF electrode without any additional modification shows an exceptionally high catalytic current of 397 mA cm^{-2} at a low overpotential (η) of 320 mV, a small Tafel slope of 44 mV $decade^{-1}$, a turnover frequency of 6.5 × 10^{-2} s^{-1} at η = 320 mV, and excellent stability at various current densities. Furthermore, an electrolyzer is assembled using two symmetrical Co_3Se_4/CF electrodes as anode and cathode, respectively, which can deliver 10 and 20 mA cm^{-2} at low cell voltages of 1.59 and 1.63 V. More significantly, the electrolyzer can operate at 10 mA cm^{-2} for >3500 hours and 100 mA cm^{-2} for ca. 2000 hours without noticeable degradation, showing extraordinary operational stability.

References

[1] Y. Liu, H. Cheng, M. Lyu, S. Fan, Q. Liu, W. Zhang, Y. Zhi, C. Wang, C. Xiao, S. Wei, B. Ye, Y. Xie, J. Am. Chem. Soc. 136 (2014) 15670

[2] W. Li, X.F. Gao, D. H. Xiong, F. Wei, W. G. Song, J. Y. Xu, L. D. Liu, submitted

Figures

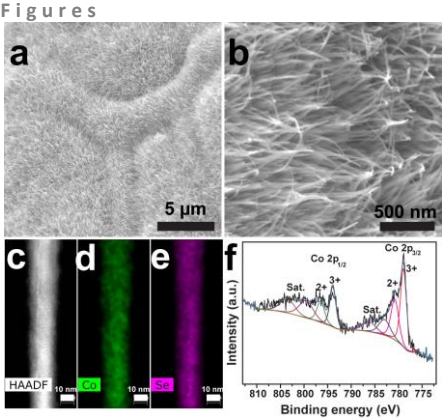

Figure 1: (a,b) SEM images of Co_3Se_4 nanowire arrays grown on Co foam. (c-d) HAADF-STEM image and elemental maps of Co and Se taken from a single nanowire. (f) XPS spectrum of Co 2p core level.

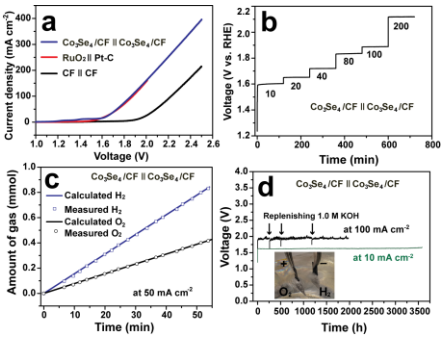

Figure 2: Overall water splitting performance of the two-electrode electrolyzers. (a) Polarization curves of Co_3Se_4/CF, CF and RuO_2(+) Pt-C(-) supported on CF. (b) Multi-step chronopotentiometric (CP) curve of the Co_3Se_4/CF electrolyzer at varying current densities. (c) Gas yield of H_2 and O_2 evolved over the Co_3Se_4/CF electrodes as a function of time at 50 mA cm^{-2}. (d) Long-term stability CP test of the Co_3Se_4/CF electrolyzer at 10 and 100 mA cm^{-2}. Inset is a photograph showing the gas bubbling of H_2 from cathode and O_2 from anode at 100 mA cm^{-2}. All experiments were conducted in 1.0 M KOH at room temperature. The polarization and CP curves were shown without iR correction (i.e., including real resistive loss).