Hexagonal Boron Nitride-Encapsulated Nickel Boride Thin Film as an Electrocatalyst for Hydrogen Evolution Reaction

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Abstract

Nickel boride catalysts show great potential as low-cost and efficient alternatives to noble-metal catalysts in acidic media; however, synthesizing and isolating a specific phase and composition of nickel boride is nontrivial, and issues persist in their long-term stability as electrocatalysts. Here, we present that single-crystal nickel boride, $Ni_{23}B_6$, exhibits high electrocatalytic activity for the hydrogen evolution reaction (HER) in acidic solution, and that its poor long-term stability can be overcome via encapsulation by a single-crystal trilayer hexagonal boron–nitride (hBN) film. Interestingly, hBN-covered $Ni_{23}B_6$ on a Ni substrate shows an identical overpotential of 52 mV at a current density of 10 mA cm^{-2} to that of bare $Ni_{23}B_6$ on a Ni substrate. This phenomenon indicates that the single-crystalline hBN layer is catalytically transparent and does not obstruct HER activation. The hBN/$Ni_{23}B_6$/Ni cathode has remarkable long-term stability with negligible changes to its polarization curves for 2000 cycles, whereas the $Ni_{23}B_6$/Ni cathode shows significant degradation after 650 cycles. Furthermore, chronoamperometric measurements indicate stability is preserved for >20 h. Long-term stability tests also reveal that the surface morphology and chemical structure of the hBN/$Ni_{23}B_6$/Ni electrode remain preserved. This work provides a model for the practical design of robust and durable electrochemical catalysts through the use of hBN encapsulation.

Figures

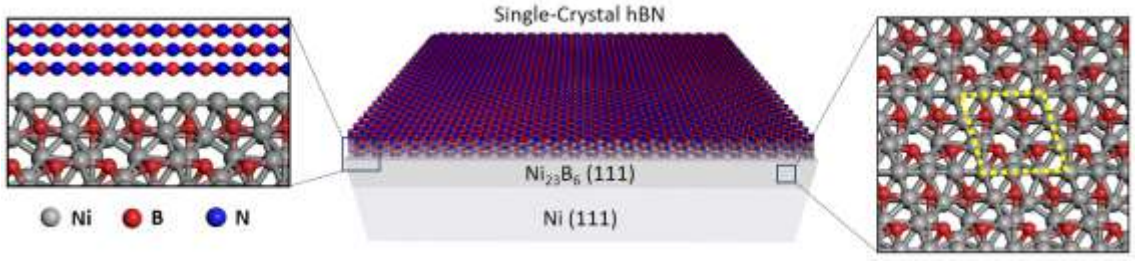

Figure 1: Schematic illustration of the cathode comprising single-crystalline trilayer hBN film covering the $Ni_{23}B_6$ cathode.