Binary and Ternary Anisotropic Core-Shell Nanosandwiches with Composition Tunable Core for Oxygen Evolution Reaction

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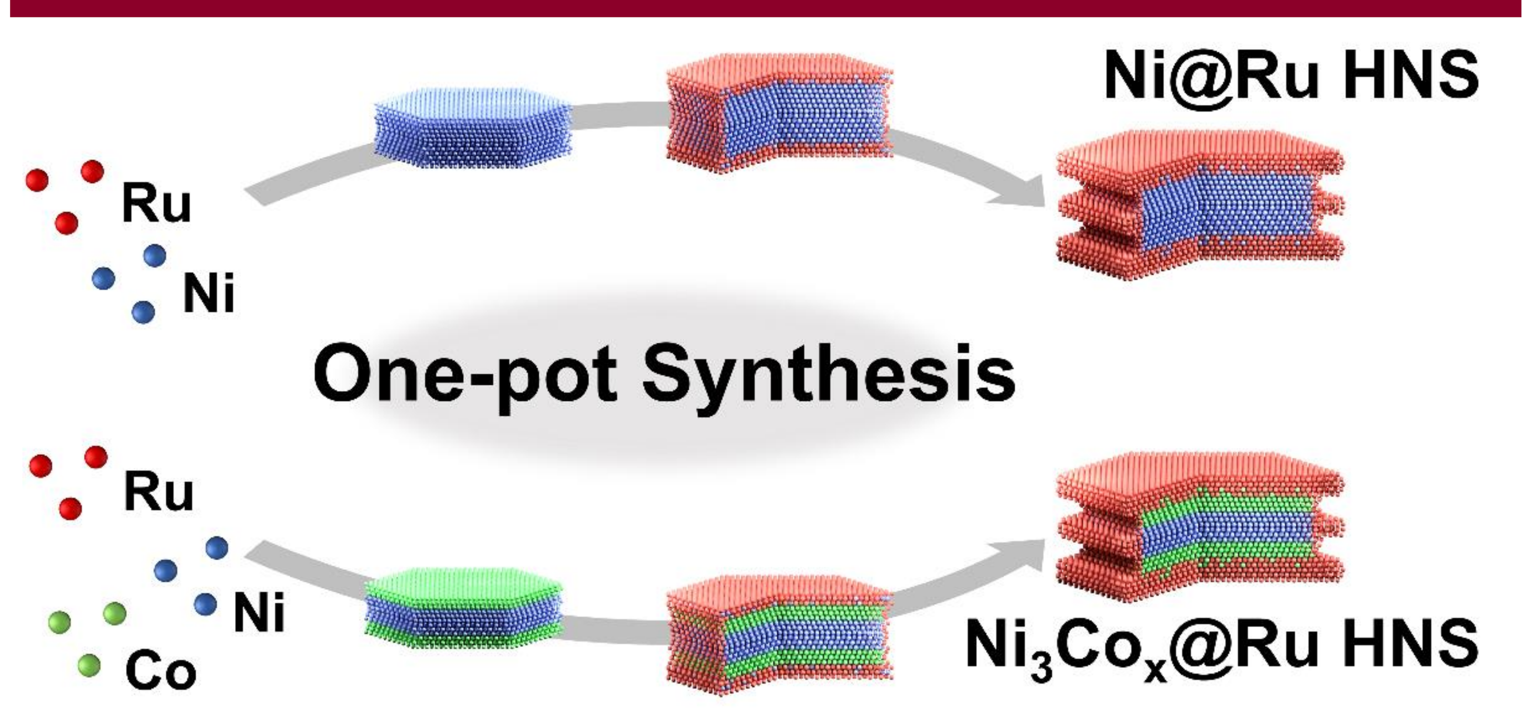
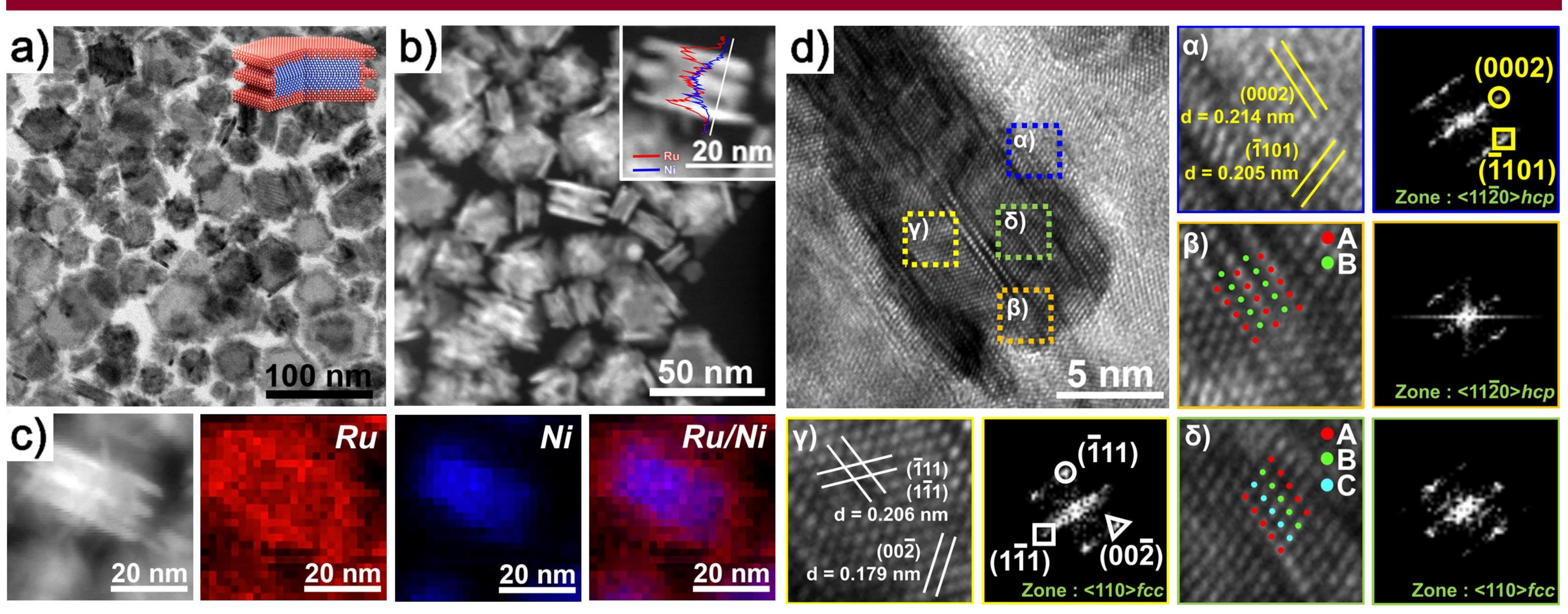
Abstract

Development of electrocatalysts with reduced noble metal content with enhanced catalytic performance has been of importance in cost-effective design of renewable energy conversion devices. The design of core-shell nanoparticles as electrocatalysts represents a promising approach for preparing not only limiting the use of expensive precious metals also developing catalytic activity. Herein, simple one-pot synthetic route to fabricate anisotropic hexagonal-shaped core-shell nanosandwich structures with binary and ternary composition will be reported. Also, the core composition of hexagonal nanosandwich structures is easily controllable by modulating the amount of precursor. The hexagonal core-shell nanosandwich possesses enhanced electrocatalytic activity toward oxygen evolution reaction (OER), with their OER activity being dependent on their core compositions.

Synthetic Scheme

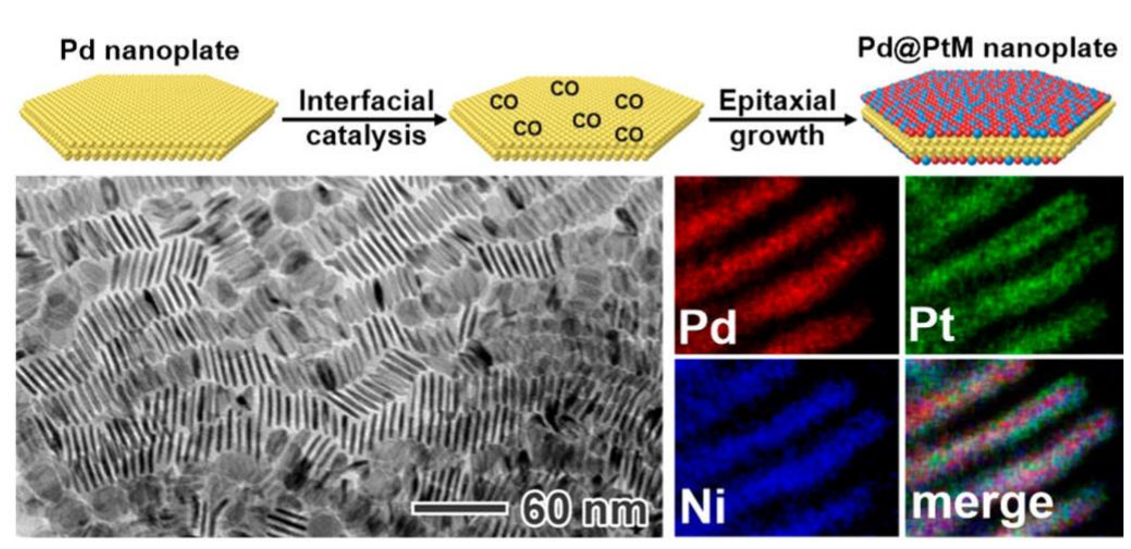


Ni@Ru Hexagonal Nanosandwiches (Ni@Ru HNS)



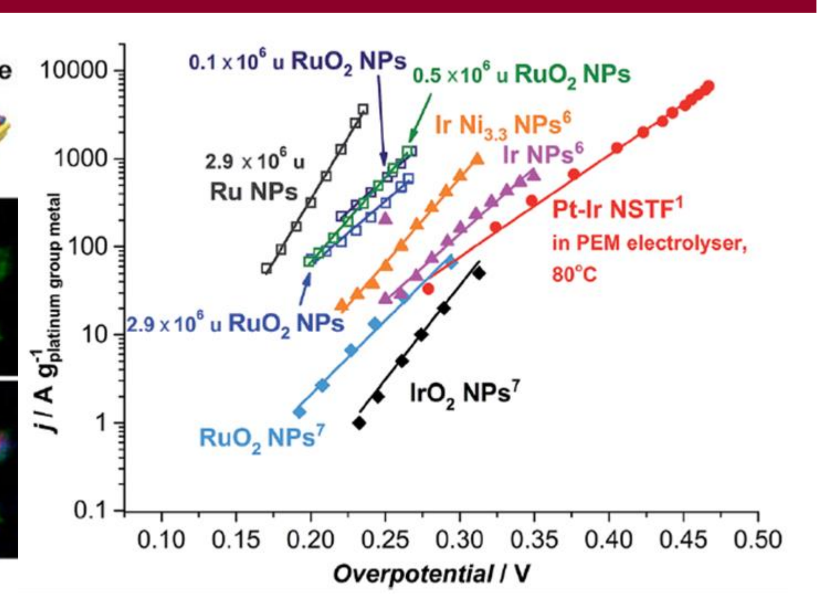
(a) TEM image of Ni@Ru HNS (inset: schematic model of Ni@Ru HNS). (b) HAADF-STEM image of Ni@Ru HNS (inset: corresponding EDS line profile analysis). (c) HAADF-STEM image and its corresponding EDS elemental mapping analysis. (d) HRTEM image of Ni@Ru HNS. Enlarged area shows coexistence of both fcc and hcp crystal packing in Ni@Ru HNS structure.

References



Y. Yan *et al*, *Nano Lett.*, *16*, 7999. **(2016)**

Anisotropic multimetallic core@shell nanostructure



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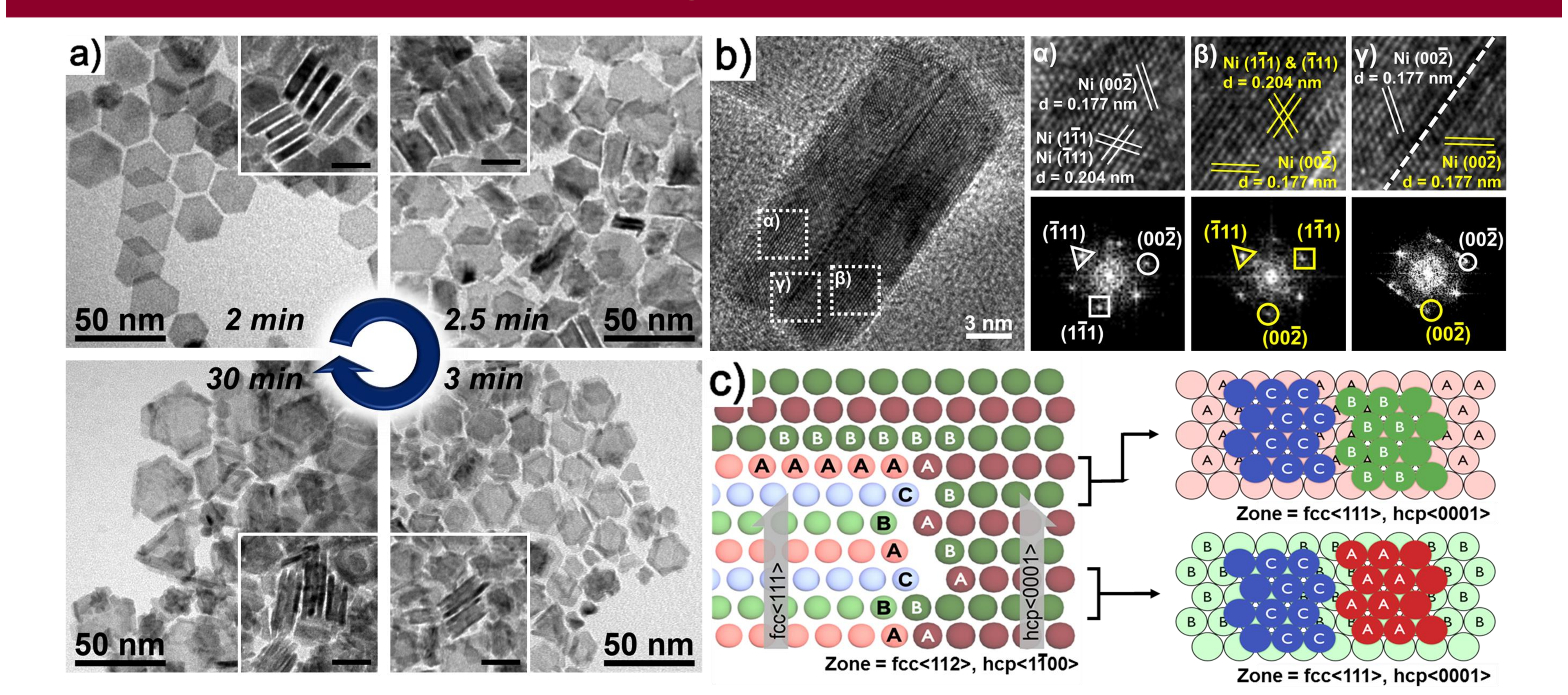
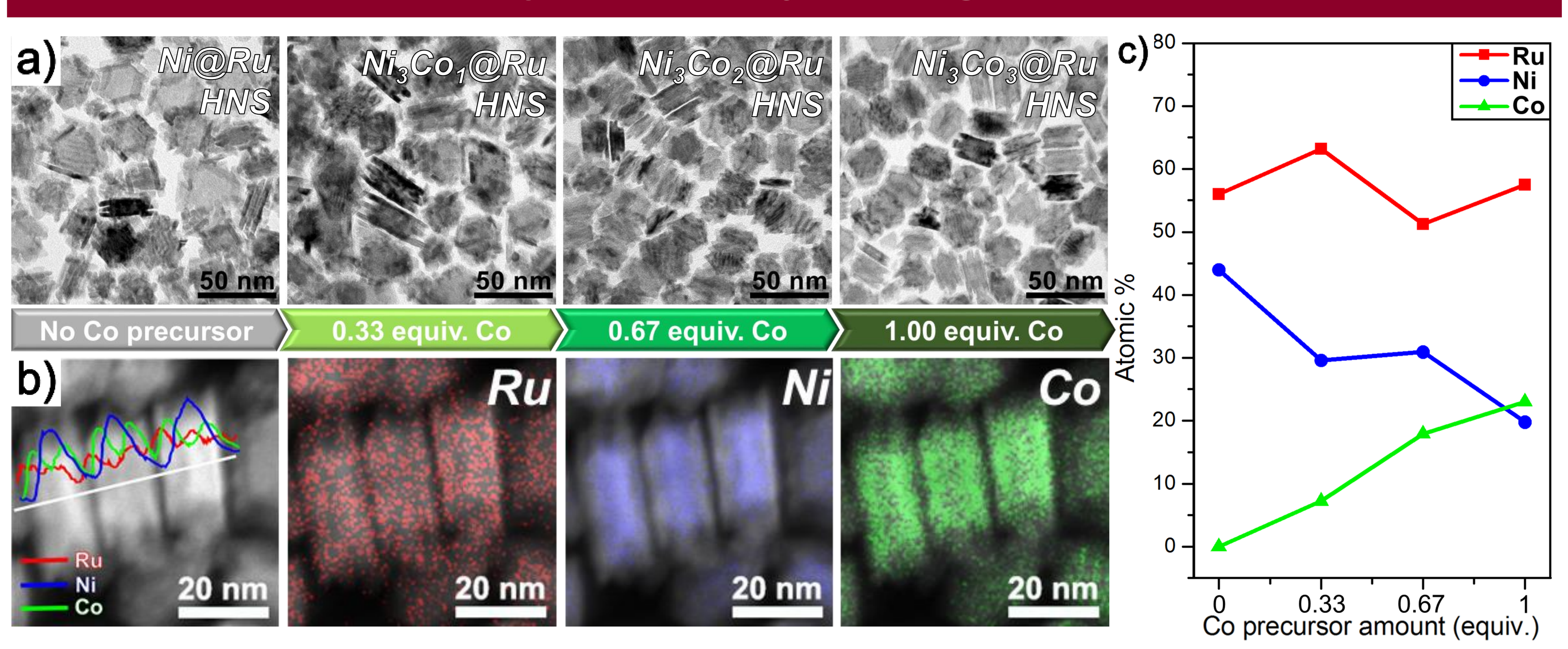
Ru-based electrocatalysts for oxygen evolution reaction

Formation Mechanism of Ni@Ru HNS Structure



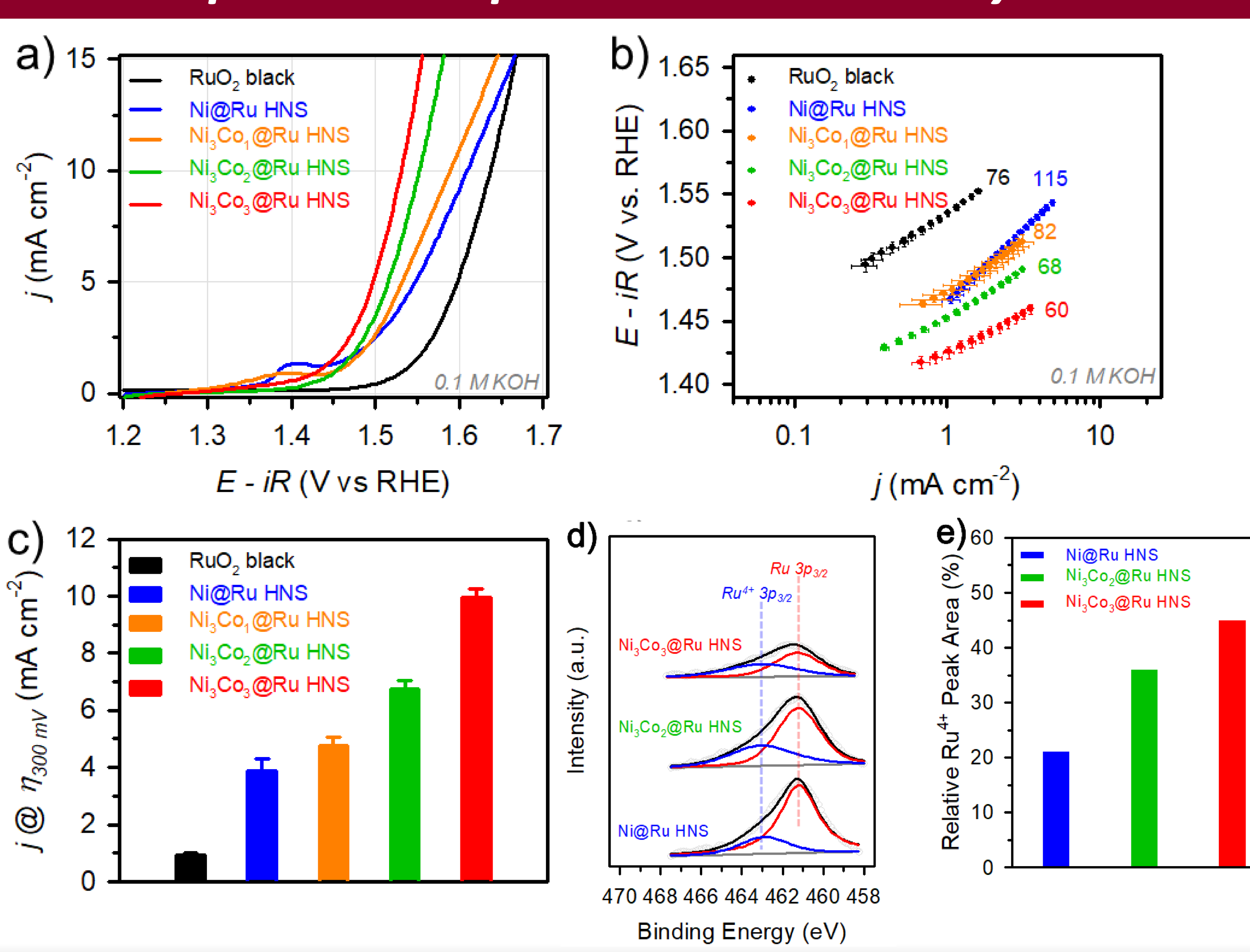
(a) TEM image of reaction intermediates of Ni@Ru HNS (inset: side view). (b) HRTEM image of 2 min reaction intermediates. (c) Schematic illustration of atomic packing models for side face of Ni@Ru HNS.

Tunable Core Composition of Hexagonal Nanosandwich



(a) TEM image of $Ni_3Co_x@Ru$ HNS with different amount of Co precursor. (b) HAADF-STEM image and its corresponding EDS line profile and elemental mapping analysis of Ni_3Co_3 HNS. (c) Change in Ru, Ni, and Co atomic percent measured by EDS spectrum.

Core Composition Dependent OER Activity



(a) OER polarization curves of Ni@Ru HNS, $Ni_3Co_x@Ru$ HNS and RuO_2 black catalysts in 0.1 M KOH. (b) Tafel plots of electrocatalysts. Tafel slopes are given in the plot. (c) Comparision of current densities at 1.53 V (*vs.* RHE). (d) Ru $3p_{3/2}$ X-ray photoelectron spectroscopy (XPS) spectra of Ni@Ru HNS, $Ni_3Co_2@Ru$ HNS and $Ni_3Co_3@Ru$ HNS. (b) Relative peak area of Ru^{4+} from deconvoluted Ru $3p_{3/2}$ XPS spectra.

Conclusion

We have successfully prepared novel binary Ni@Ru and ternary $Ni_3Co_x@Ru$ HNS with a hexagonal sandwich-like shape. The core composition of $Ni_3Co_x@Ru$ HNS is controllable without altering their size or nanoplate shape. Notably, the Ru shell layer is overgrown regio-selectively at the top and bottom of cores and around its center section. The HNS structures show core-composition dependent OER activity under alkaline condition, which can be correlated to changes in the oxidation state of the Ru shell layer.

Acknowledgement

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