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ABSTRACT:

Durability First: Interface Engineering and Protective Coatings for Cost-Competitive Photoelectrochemical Hydrogen

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Photoelectrochemical (PEC) water splitting has surpassed 20% solar-to-hydrogen (STH) efficiency on small electrodes [1], and segmented modules retain 11.2% on 16 cm2 [2], yet no one-sun device has combined STH >10%, >1,000 h of operation and >100 cm2 of area. This contribution analyses that gap.

Detailed-balance limits cap oxide photoanodes at about 9% (BiVO4) and 15% (α-Fe2O3) STH, whereas perovskite/Si tandems can approach 27% but survive in water only behind engineered interfaces. Atomiclayer-deposited oxides, impermeable conductive barriers, buried junctions and in situ formed surfaces (Ga–O–N on GaN/Si, 3,000 h [3]) are compared. A levelised-cost model (Fig. 1) shows that, at the 100–150 h lifetimes reached so far, hydrogen would cost more than USD 50 kg−1 even at 20.8% STH, whereas ten-year photoelectrodes at 150 USD m−2 reach USD 3 kg−1 with about 13% STH. A tiered two-electrode and outdoor durability protocol and a gated roadmap to pilot scale by 2035 are proposed.

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[1] A.M.K. Fehr, A. Agrawal, F. Mandani et al., Nat. Commun., 14, 3797 (2023).
[2] D. Hansora, R. Mehrotra, E. Noh et al., Nat. Commun., 16, 4186 (2025).
[3] Y. Xiao, X. Kong, S. Vanka et al., Nat. Commun., 14, 2047 (2023).