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III-V Nitrides and Tandem Cells for Photoelectrochemical Water Splitting

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Forty years after the first reported photoelectrochemcial (PEC) water splitting experiment, the promise of hydrogen production from photoelectrochemical water splitting remains just that, a promise. Thousands of papers later and no material system has been identified that could fulfill the promise of hydrogen production from the direct splitting of water using sunlight as the only energy input.

Recent technonomic analysis studies indicate that for a commercially viable PEC-based water splitting system, the solar-to-hydrogen conversion efficiencies need to approach 20%. The highest efficiency to-date for water splitting using visible light is the GaAs/$GaInP_2$ PV/PEC tandem cell with a published efficiency of 12.4%. This is not surprising since III-V based solar cells have the highest reported photovoltaic efficiency. Unfortunately, this material system has not shown the necessary long-term stability. Stabilizing the system using surface treatments or solution additives may be possible but another approach is to identify III-V materials with inherently greater stability.

Our previous studies of dilute III-V nitrides showed that they have greater stability over the pure phosphides, but suffer from poor electronic properties. The pure nitride materials used in white-light LEDs have shown better electronic properties and these alloys appear to be a fruitful area of research.

We have grown InGaN alloys with bandgaps close to the range necessary for efficient water splitting and characterized their properties for PEC water splitting. We have also investigated dilute bismides as possible low band semiconductors for the bottom cell in a tandem configuration.

This report will summarize our efforts on these materials and their application to tandem cells for photoelectrochemical water splitting.