PHYSICS
COLORADO STATE UNIVERSITY

# CSU PHYSICS COLLOQUIUM

Photocurrent Mapping of Ultra-Thin Liquid Junction Solar Cells

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## Abstract

Semiconducting transition metal dichalcogenide nanoflake thin films such as $MoX_2$ and $WX_2$ (where X = S or Se) are promising large-area electrodes for photoelectrochemical solar energy conversion applications. However, their energy conversion efficiencies are typically much lower than bulk electrodes. It is unclear to what extent this efficiency gap stems from differences among nanoflakes (e.g., area, thickness, and surface structural features). It is also unclear whether individual exfoliated nanoflakes can achieve similar energy conversion efficiencies to bulk crystals. Here we use a single-nanoflake photoelectrochemical approach to show that there are both highly active and completely inactive nanoflakes within a film. For the exfoliated $MoSe_2$ samples studied herein, 7% of nanoflakes are highly active "champions" whose photocurrent efficiency exceed that of the bulk crystal. However, ~66% of nanoflakes are inactive "spectators" that are mostly

responsible for the overall lower photocurrent efficiency compared to the bulk crystal. The photocurrent collection efficiency increases with nanoflake area and decreases more at perimeter edges than at interior step edges. These observations, which are hidden in ensemble-level measurements, reveal underlying performance issues of exfoliated TMD electrodes for photoelectrochemical energy conversion applications.