Nanostructured MoS_2 Electrodes for use in Solar Cells

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Summary

Quantum dot sensitized solar cells (QDSSCs) are a widely studied system for harvesting light and converting it to electrical energy. Quantum dots (QDs) are an attractive photoabsorber because they have large absorption coefficients and their energy of absorption in the visible region can be tuned based on their size. Molybdenum (IV) disulfide (MoS_2) is a naturally occurring semiconductor found in nature as the mineral molybdenite that can be synthesized from inexpensive, earth-abundant materials for use in solar cells.

Addressed Need

Great strides are being made into developing new, more efficient absorber layers on the photoanode; however, instability of the cathode material prevents these cells from working effectively for more than a few seconds. Platinum, the most common counter electrode used for the study of QDSSCs, as well as gold and glassy carbon quickly become poisoned by the sulfide, resulting in significant current drops. Thus, these materials require large overpotentials to operate, lowering solar cell efficiencies and making them unsuitable for long-term use in a device. Also, platinum is rare and expensive, so replacing it with an inexpensive, earth-abundant material is a desirable goal. Molybdenum (Mo) displays properties that make it a suitable alternative to the materials listed above for use in solar cells.

Technology Description

Edge sites where Mo is exposed – not the faces – of nano-MoS_2 are the catalytic sites for electrochemical H2 evolution, so maximizing the relative number of edge sites to facial sites will improve electrochemical activity in a cell. Existing techniques can be employed to produce flower-like MoS_2 microspheres with uniform size and distinct petal shapes. Producing a uniform layer of these nano-flowers on a substrate would create an ideal counter electrode for QDSSCs, but previous attempts to deposit such structures on a substrate have largely been unsuccessful. The present technology uses a Mo foil to produce the desired uniform growth of MoS_2 petals from the Mo foil, making the foil both the source of Mo as well as the substrate.

Unique Features

- Petaled MoS_2 electrodes show a cell efficiency increase of at least 140% compared to cells prepared with either Pt and Au cathodes
- Further, petaled MoS_2 electrodes lost only 0.63% of their initial current density at -1 V whereas Pt lost 13.58% after only five scans, indicating the petaled MoS_2 films are highly stable as cathodes
- Petaled MoS_2 achieved current densities at least six times higher than other common electrode materials, as shown in Figure 1 below

Intellectual Property Status

U.S. patent issued - 9,496,094

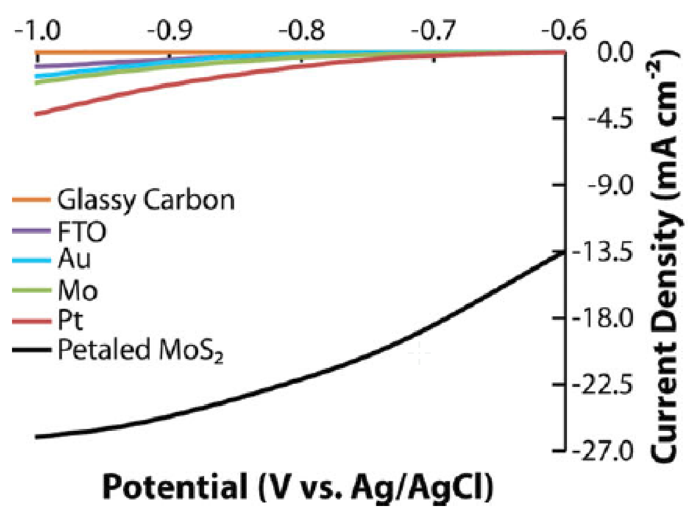

Figure 1: linear sweep voltammetry of various electrode materials in polysulfide solution showing much higher achievable current densities with petaled MoS_2 electrodes than many other common materials such as high surface area Pt, Mo, Au, FTO, and glassy carbon.

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