Synthesis and application of doped cesium polytungstate nanosheets

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With the rapid urbanization in the world since 2000, reducing urban energy consumption has become one of the most important goals for achieving carbon neutrality.[1] To achieve this goal, thermal shielding materials are widely used for window coatings in the architecture and automotive industries. By shielding near-infrared (NIR) light from the sunlight, it conditions the temperature of the buildings or automobiles, thus reducing the use of air conditioner and its energy consumption.

Commonly utilized materials for NIR light shielding window coatings are transparent conductive oxides (TCOs) such as indium-doped tin oxide, fluorine-doped tin oxide, gallium doped zinc oxide and tungsten trioxide-based materials. Among them, tungsten trioxide-based materials have attracted great interests over the past decade due to their low cost, and tunable optical properties through accommodation of tunnel inserted ions and generation of oxygen vacancies.

In previous work, a thermal reduced 2D cesium tungsten bronze (CTB) nanosheet, $Cs_3W_{11}O_{35\text{-}d}$, was synthesized through liquid phase exfoliation and well-established gas flow reduction [2]. It's proved to be of great potential as a thermal shielding coating material attributed to the remarkable localized surface plasmon resonance (LSPR) effect coming from the 2D morphology.[2] However, another important mechanism for NIR light shielding in tungsten trioxide-based material, the polaron effect, was not prominent, which means there is an opportunity to further modify the electronic structure in pursuit of greater performance. According to previous research, the doping on tungsten site is proved to be effective on the enhancement of polaron effect by introducing trapped electron states.[3]

Herein, in the present study, the effects of tungsten site doping are investigated based on the 2D CTB from previous work. Firstly, doped cesium polytungstate $Cs_4W_{11\text{-}x}MxO_{35}$(M= Nb, Mo) is synthesized through solid state reaction. Subsequently, liquid phase exfoliation is conducted to obtain $Cs_3W_{11\text{-}x}MxO_{35}^-$ nanosheet colloidal solution. Furthermore, single-droplet assembly is applied to obtain multilayer nanosheet films.[4] Finally, carriers injection into the as-deposited film is conducted through thermal reduction to modify its LSPR effect, and attempt to synergize LSPR effect with polaron effect toward enhanced NIR light shielding performance. Our study will develop an enhanced thermal shielding film for temperature conditioning and energy saving.

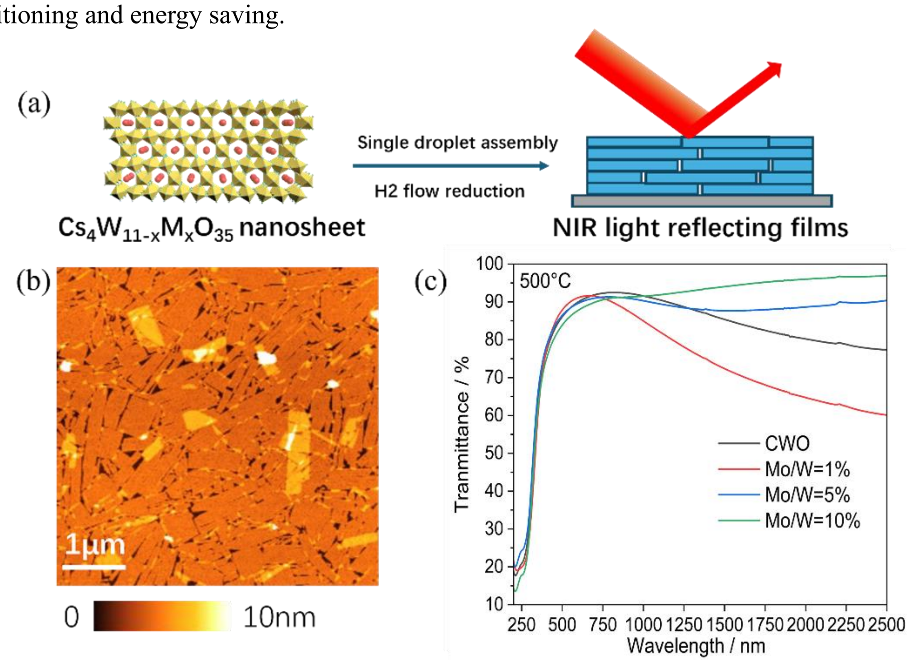

Fig1. (a) Graphic abstract for the present research. (b) AFM image of thermally reduced nanosheet film. (c) NIR light shielding performance of Mo-doped 2D CTB with Mo/W ratio of 0.5, 1 and 2.

Reference:

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[3] T. Wang *et al.*, *RSC Adv.*, **4**(2014), 43366.

[4] Y. Shi *et al.*, *ACS Nano*, **14**(2020), 15216-15226.