Plasma-Treated and Doped WS_2 Nanoparticles for Energy Applications

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Multiwall WS_2 nanotubes and polyhedral fullerene-like nanoparticles were discovered in the earlier 1990s. An efficient synthesis method for the scaled-up production of high purity inorganic fullerene WS_2 nanoparticles was later developed, which allows to produce tens of kilograms per day. The availability of these nanomaterials led to investigation of their properties, and stimulated numerous applications in energy related applications, some of them have been recently investigated by us and include hydrogen storage [1], electrocatalysts [2], and solar cells [3].

We developed a new method of surface modification of WS_2 nanotubes through cold radiofrequency (RF) plasma for hydrogen evolution reaction (HER). The effect of plasmatic ions on WS_2 nanotubes has been investigated. The plasma-treated samples showed improved performances in HER electrocatalysis. Both Ar and D_2 RF plasma treatments, when performed separately, show similar effects on electrocatalysis performances with improved HER overpotentials of ~340 mV at 10mA/cm^2 compared to 567 mV of the pristine WS_2 nanotubes, whereas the combined treatment by Ar and then by D_2 RF plasma notably decreased the overpotential to 264 mV.

Additional, currently developed application of WS_2 nanoparticles is to integrate them in perovskite solar cells (PSCs). Photoinduced degradation, thermal effects, and chemical reactions result in degradation of such PSCs. Using our currently developing approach we aim to overcome their instability by developing the novel hybrid PSC/MS_2 nanocomposites, as shown in Fig. 1. MS_2 (M = W or Mo) nanotubes are capable of absorbing a wide range of visible light and are very stable. Combining MS_2 nanotubes and perovskites can increase the stability of so produced composite. As MS_2 nanotubes support polaritonic modes at room temperature, they are optically active in Vis and NIR-IR regions and so can be utilized for light absorption and emission across this spectral range. The composites of perovskites/MS_2 nanotubes offer an additional benefit of charge transfer. For this purpose, they are being exposed to focused ion beams to induce Ga implantation so achieving the improvement of their conductivity and decrease of the band gap [4].

References

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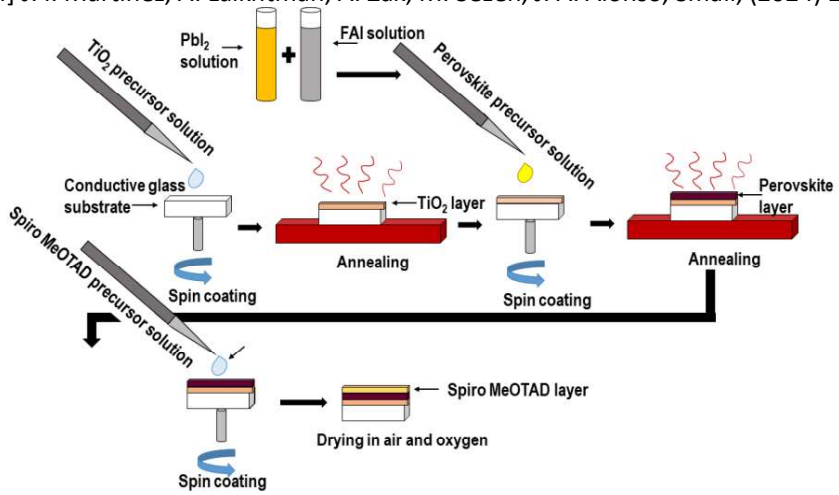

Figure 1: Schematic view of the steps in the WS_2/PSC assembly.