**Controllable growth of Cu2ZnSnSe4 Thin Film by Magnetron Sputtering Method and Solar Cell**

*Yi ZhangA, Li Wu,B, Jianjun LiA, Shoushuai GaoA,*

A Institute of Photoelectronic Thin Film Devices and Technology, Nankai University, Tianjin, China; B School of Physics, Nankai University, Tianjin, China.

Thin film solar cells based on Cu2ZnSn(S,Se)4 (CZTSSe) light absorbing materials continue to attract attention from both scientific and industrial community owing to their advantage of using earth abundant and low cost source elements. The remarkable performance enhancement of CZTSSe solar cells to over 12% has indicated the huge potential of this type of new PV technology to deliver cost-effective solar electricity to meet the demand of rapidly increasing electricity usage in today’s world. To date, most of the reported high performance CZTSSe solar cells with efficiency above 10% were fabricated by hydrazine-based process, including the 12.7% champion device. However, the extremely toxic and explosive hydrazine may cause practical issues that can restrict the large scale production of CZTS solar cells by this method in the future. Thus development of safe method for fabrication of high performance CZTS solar cells is of highly importance for this new PV technology to fulfill its mission in the future.

Herein, we present the study of fabrication of high performance CZTSSe thin film solar cells with efficiency above 10% using magnetron sputtering deposition. First, CZTSSe film with different stacking sequence are investigated systematically to uncover the growth mechanism of CZTSSe layer and the effect of stacking order in precursor films on the performance of solar cells. It is disclosed that Cu layer should be prepared as the top layer and S will be substituted mostly because of its high saturation vapor pressure. Because Mo/CZTSSe interface is unstable and the interfacial MoSe2/MoS2 will be formed during high temperature annealing process, which increases the series resistance and deteriorate the performance of CZTSSe solar cells dramatically. For this problem, a simple, feasible and effective way to control the formation of interfacial MoSe2 in fabricating Cu2ZnSnSe4 (CZTSe) solar cells without any additional barrier layer is studied. On this basis, the growth of CZTSSe film under controllable Se vapour composition and impact of low Cu content on solar cell efficiency are studied and a 10.4% efficiency CZTSe solar cell is fabricated. We also study the effect of depletion region width of CZTSSe on the performance of solar cell.

Corresponding author: yizhang@nankai.edu.cn