Effects Of Layer Thickness On The Residual Stresses Of CIGS Solar Cells With Polyimide Substrate

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Abstract

Copper indium gallium diselenide (CIGS) solar cell is one of widely used flexible solar cells, which typically consists of an n-type ZnO (200 - 600 nm), n-type CdS (50 - 70 nm), p-type CIGS (0.5 - 3 μm), back contact Mo (0.5 - 1 μm), and PI substrate (12.5 - 75 μm). In this research, we investigate the effect of layer thickness on the residual stresses of CIGS solar cells with polyimide substrate caused by CIGS layer deposition at 400 °C and then cooling down to room temperature using COMSOL®. Moreover, we also examined the effect of layer thickness on residual stress of CIGS solar cells after cooling down to room temperature from the hotspot temperatures of 200, 300, and 400 °C. Our simulated CIGS is composed of five layers: ZnO, CdS, CIGS, Mo, and PI substrate. We were able to quantify the effect of each layer's thickness and hotspot temperature on the average stresses of each layer for the CIGS solar cells. We found that the PI substrate layer has the most significant effect on the residual stress of CIGS solar cells. Our simulation results reveal that the stress type (tensile vs. compressive) and the magnitude of stress of the CIGS layer (main absorber layer) can be controlled by changing the thickness of the PI substrate while applying a heat to CIGS solar cells. Quantitative analysis of relationship between layer thickness and thermo-mechanical stress of thin film solar cells can help solar cell manufacturers design more robust and reliable solar cells.

Setup:
1. Generated each layer of CIGS cell (2D) using COMSOL® geometry tool
2. Assign Thermal Expansion coefficient, Young's modulus, Poisson's ratio, and density for each layer
3. Structural Mechanics Module with a stationary study was used
4. Thermal Expansion attribute under the Linear Elastic Material domain is used to generate the residual stress due to temperature change
5. Rigid Motion Suppression node is used to prevent the rigid body motion
6. We adopted the "Layered Plate" model from the Application Library

Figures used in the abstract

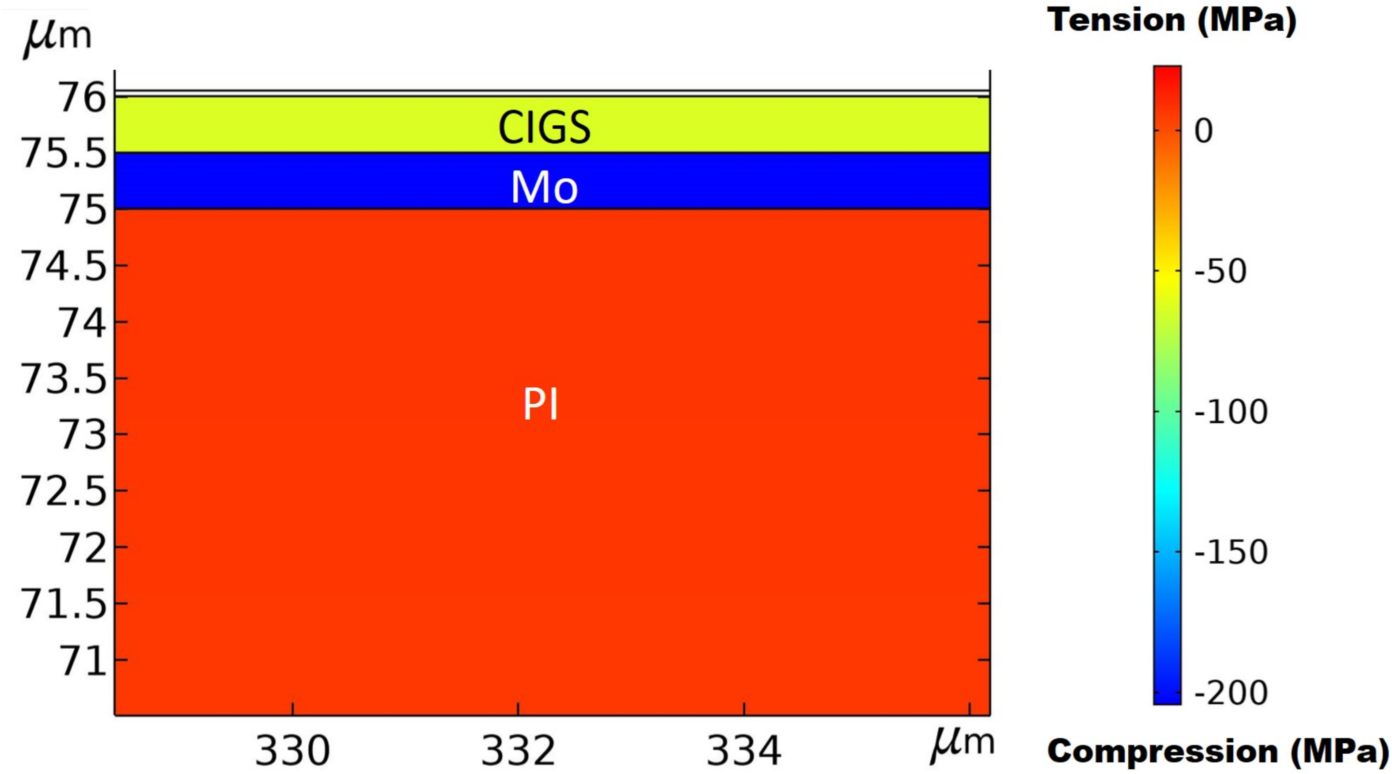

Figure 1 : Stress distribution of a CIGS cell consisting of PI, Mo, and CIGS after depositing CIGS layer at 400 ˚C and cooling down to room temperature. For a clear visualization, the stress distribution in a small area (5 x 6 μm) is illustrated.

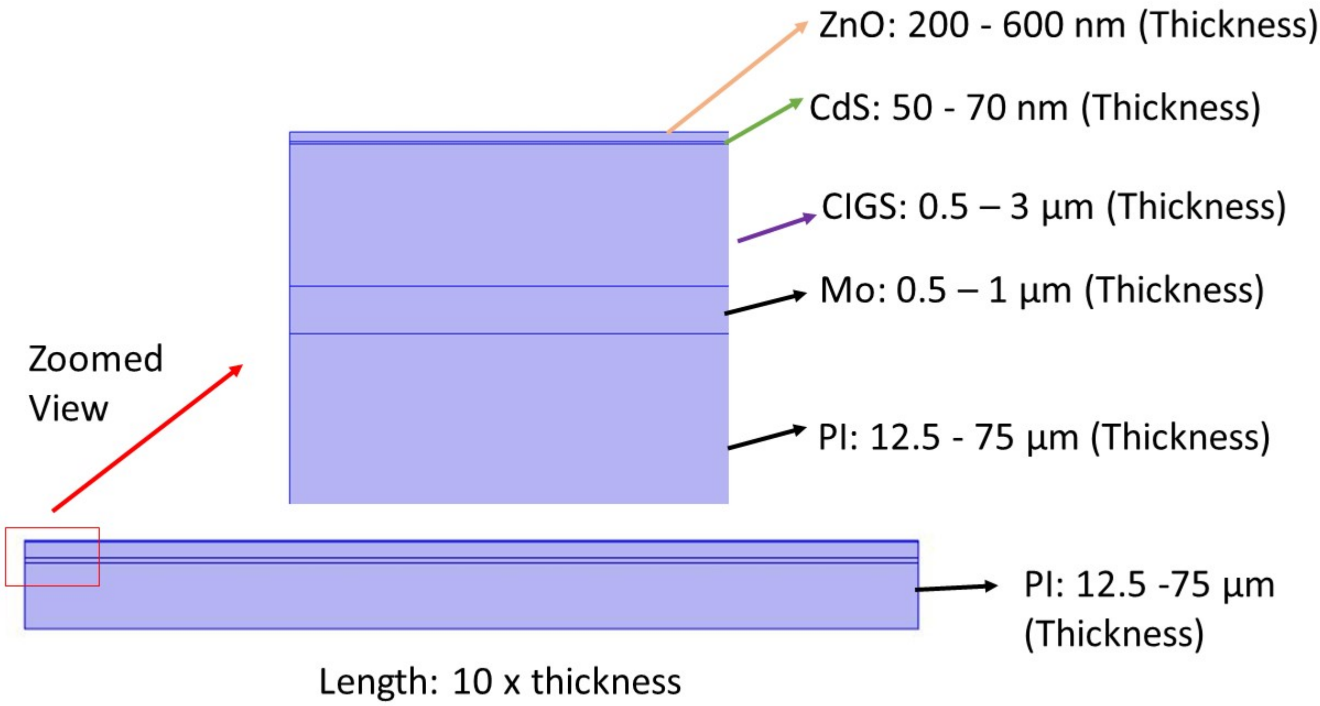

Figure 2 : CIGS solar cell dimension