Origins of varying carrier concentration in Cu$_2$SnS$_3$ photovoltaic absorbers LAURYN BARANOWSKI, Colorado School of Mines, National Renewable Energy Laboratory, PAWEL ZAWADZKI, STEPHAN LANY, WILLIAM TUMAS, DAVID GINLEY, National Renewable Energy Laboratory, ERIC TOBERER, Colorado School of Mines, National Renewable Energy Laboratory, ANDRIY ZALKUTAYEV, National Renewable Energy Laboratory — Within the Cu-Sn-S family of earth abundant photovoltaic absorbers, the Cu$_2$SnS$_3$ phase is predicted to be the most promising absorber material [P. Zawadzki, et al.]. To date there has been limited synthetic work on the Cu$_2$SnS$_3$ phase, particularly the carrier concentration. In this study, we develop an understanding of the effects of RF sputtering growth conditions on the hole concentrations of Cu$_2$SnS$_3$ absorber films, and use these results to identify the underlying causes of the observed variations in carrier concentration. Two effects are identified that control the carrier concentration in Cu$_2$SnS$_3$ films. The first effect, which occurs during Cu-rich growth, is isostructural alloying with a metallic Cu$_3$SnS$_4$ phase, which gives rise to hole concentrations above $10^{19}$ cm$^{-3}$. The second effect is that, when the Cu$_2$SnS$_3$ films are grown under Sn-rich conditions, varying the S chemical potential during film deposition gives $10^{18}$-$10^{19}$ cm$^{-3}$ holes. This variation in carrier concentration with S chemical potential can be explained by a Cu vacancy defect model. Understanding the origins of the varying doping density in Cu$_2$SnS$_3$ films allows for targeted growth to achieve desired carrier concentrations for device integration.

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