

## Experiments with CuInSe<sub>2</sub> plus added sodium

H.F. Myers<sup>\*</sup>, C.H. Champness([clifford.champness@mcgill.ca](mailto:clifford.champness@mcgill.ca)), I. Shih

---

The addition of a small quantity of sodium to the preparation of solar cells, using Cu(InGa)Se<sub>2</sub> (CIGS) as the absorber layer, has been shown to increase the photovoltaic conversion efficiency significantly. Such cells are usually of the form Mo-CIGS-CdS-(ZnO)<sub>i</sub>-(ZnO)<sub>c</sub>-Al, where the CIGS is a 2-micrometer film of polycrystalline material with micron-sized crystal grains, (ZnO)<sub>i</sub> represents sputtered insulating zinc oxide and (ZnO)<sub>c</sub>, the conducting form of this binary compound. Several theories have been proposed for the beneficial effect of added sodium. Some of these are that the Na in small quantities (1) improves crystallinity by enlarging the grain size, (2) increases preferred grain orientation, (3) increases electrical conductivity and (4) reduces the concentration of recombination centers. The sodium appears to deposit itself on grain boundaries and does not penetrate deeply into the grain. However, these explanations are not completely satisfying and have not been completely proved. Since grain boundaries are present in polycrystalline material, it makes sense to examine what happens in bulk monocrystals, where ideally there are no grains. Furthermore, the beneficial sodium effect occurs as well in cells made with the ternary basic compound CuInSe<sub>2</sub>, so that a simplification of the problem would be to study this material in single crystal form, rather than the quaternary Cu(InGa)Se<sub>2</sub>, with its additional Ga content. Accordingly, experiments have been carried out in this laboratory to grow monocrystals of CuInSe<sub>2</sub> from a liquid melt containing small amounts of Na and Na<sub>2</sub>Se using a vertical Bridgman method. It was found that the addition of more than 0.1 at

---

<sup>\*</sup> Corresponding author. Tel. 514-398-7121.

*Email address:* [clifford.champness@mcgill.ca](mailto:clifford.champness@mcgill.ca) (H.F. Myers).