From a Crazy Idea to a New Semiconductor for Photovoltaics

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The talk will present an overview about a materials growth program using Alkali-Pnictogens (I_3V), a class of semiconductors with exceptional strong light absorption and unusual electronic transport properties.

These characteristics are the result of an unusual "flat" band structure, e.g. nearly k-independent density of states. Consequently, the materials show a very high density of occupied and unoccupied states close to the top of the valence and bottom of the conduction band generating an optical absorption length of less then 100nm. In addition, the conduction-valence electron scattering for hot carriers ($E_{Kin}<2xE_{Gap}$) dominates the electron-phonon scattering producing an exceptional thermalization process that creates multiple excited electron hole pairs instead of heat. In other words, the I_3V semiconductors have the potential to build not only ultra-thin, low weight solar module but also to overcome the Shockley-Queisser efficiency limit.

Despite these qualities and potential opportunities, the complex, unrevealed growth dynamics of I_3V materials, in combination with violent chemical reactivity of the individual compounds had so far prevented the brought study of this material group. Using in-situ x-ray diffraction, X-ray reflectivity, X-ray fluorescence, and optical photo-electron emission studies, we were able to visualize the growth of the material using conventional growth recipes and to develop a new sputter-based growth method.

Using the new growth method we are able to reproducibly generate smooth homogeneous p-doped films, have created a hetero-junction and develop next to the intrinsic, an extrinsic n-doping concept. Using this toolbox, we are currently developing a full hetero-pn junction not only to demonstrate a working I_3V solar cell but also to proof that I_3V solar cells overcome the Shockley-Queisser efficiency limit.

As a "lesson-learned" we will also discuss in this talk the necessary beamline requirements for dedicated in-situ beamlines and their implementations at the spectroscopy beamline ISS at NSL-II.