Bio-Inspired Band-Gap Modification of Semiconductor Cu_2O by the Incorporation of Amino Acids

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Background and motivation

Crystal formation in biological systems is fascinating and has attracted many researchers over the passed several decades. One of the most intriguing characteristics of such biogenic crystals is the presence of intracrystalline organic molecules within single crystal hosts.[1, 2] Such molecules have been proved to become well incorporated into the lattice of the inorganic crystal host and exert systematic anisotropic lattice distortions as well as distinctive/unique microstructures.[3, 4] Having been mainly demonstrated within the calcium carbonate system we have been performing bio-inspired studies of synthetically incorporating molecules within other crystalline systems such as semiconductors.[5]

Results and Discussion

Herein we report that we can induce similar lattice distortions in vitro by growing semiconductor crystals of Cu_2O from aqueous solution in the presence of different amino acids. Utilizing the dedicated high-resolution synchrotron powder diffraction allowed to extract structural information with the highest precision and analyze the microstructure evolution produced by incorporation of amino acids. In addition, in-situ heat treatments at elevated temperatures were carried out to investigate the temperature-generated relaxation of the lattice strains and the activation energy of relaxation.

However the paramount importance of this study is that Cu_2O semiconductor crystals not only allow for the incorporation of organic molecules but also prove the prevalence of bio-inspired band gap engineering phenomenon. For several specific amino acids the induced lattice strains were accompanied by pronounced (up to 16%) changes in the band gap of the Cu_2O host. Considering the significant effect of intracrystalline molecules on semiconductor properties the present work provides a step forward in generalization of a novel approach to band gap engineering of semiconductor crystals and may lead to discovering a new kind of bio-inspired semiconducting materials for future technological applications.

[1] Yoreo&Dove (2004) *Science* **306**, 1301-1302. [2] Berman et al (1988) *Nature* **331**, 546-548. [3] Pokroy at al (2006) *Advanced Materials* **18**, 2363. [4] Pokroy at al (2006) *J Struct Biol* **153**, 145-150. [5] Brif et al (2013) *Advanced Materials* **26**, 477–481.