doi:10.1017/S1431927616010400
Microsc. Microanal. 22 (Suppl 3), 2016

Micro-scale Self-assembly of Long-range Ordered CuS Nanostructures

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Copper sulfide (CuS) due to its unique optical, electrical, and other physical and chemical properties, has been extensively studied in the areas of lithium batteries[1] and solar cell[2], sensing, photothermal therapy, imaging, supercapacitance, drug delivery, cathode materials, nonlinear optical materials, and catalysis.
Currently, varies of 3-D CuS have been successfully synthesized by hydrothermal and solvothermal methods. In these studies, the controlled synthesis of CuS caved superstructures are very interesting due to its highly geometrical shape.[3,4] However, long-range ordered structure of CuS has not been reported.
In this study, a very simple, template-assistant solvothermal method was developed to synthesize micro-scale long-term orderly arrangement structure of CuS. This structure is self-assembled by a large number of hexagonal CuS nanoplates.

The synthesis of CuS was performed according to the following procedures: 0.4 mmol $CuCl_2$ was firstly dissolved in 50 mL deionized water with vigorous agitation to form a light green solution. Then, 1.2g Polyvinylpyrrolidone (PVP) was added to the solution under magnetic stirring. 0.4 mmol thiourea was then added after all the substance was dissolved completely. The mixture was transferred into a 100 mL Teflon- lined stainless steel autoclave and heated at 100 ^{o}C for 15 h. After cooling to room temperature naturally, the product was collected by centrifugation, washed with deionized water and ethanol, and then dried in a vacuum oven at 60 ^{o}C for 10 h.
The structure and morphologies of the as-prepared CuS were recorded on a Hitachi S-4800 scanning electron microscope (SEM). XRD (X-ray powder diffraction) pattern was operated on a Japan RigakuD/Maxr-A X-ray diffractometer equipped with graphite monochromatized high-intensity Cu Kα radiation (λ= 1.54178 Å).

Fig. 1a displays typical SEM images of the as prepared hierarchical structure of CuS. X-ray diffraction was employed to understand the identity and phase purity of as-resulting products. As depicted in Fig. 1b, the entire diffraction pattern matches well with the standard data of covellite-type CuS with hexagonal lattice parameters of a = 3.7920 Å, b = 3.7920 Å and c = 16.3440 Å (covellite, syn, JCPDS no. 06-0464).

Further detailed investigations of crystallographic features of as prepared CuS sample were performed by SAED and DF-TEM, as shown in Fig. 2. It indicates that the CuS hierarchical structure composed by two different crystallographic oriented CuS nanocrystals. [5]

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[5] A JEOL JEM-2010F was used in the study that was supported by the University of Michigan College of Engineering and NSF grant #DMR-9871177.

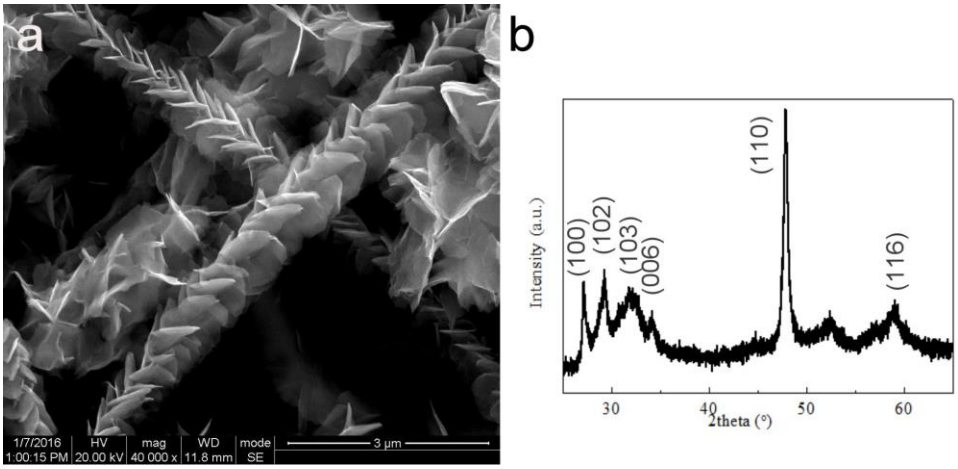

Figure 1. a) SEM image of the CuS sample, b) XRD pattern of the CuS sample, corresponding to JCPDS 06-0464.

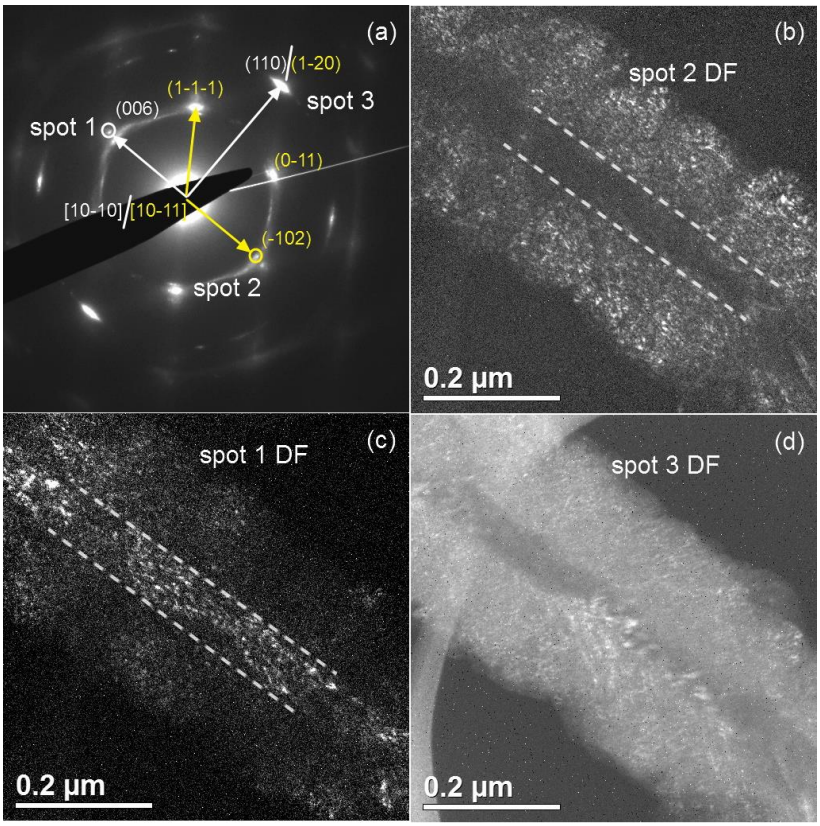

Figure 2. (a) SAED pattern of a single hierarchical structure CuS; (b), (c) and (d) are dark-field TEM images, corresponding to spot 2, spot 1 and spot 3 respectively.

https://doi.org/10.1017/S1431927616010400 Published online by Cambridge University Press