Quality assessment of gallium arsenide nanopillars using EBSD

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The need for a growing portion of sustainably produced energy has led to the development of different types of solar cells, many of them on a gallium arsenide basis. Besides conventional 2D GaAs type cells, 3D geometries such as nanopillars have been developed. GaAs nanopillars provide a large surface area at improved light conversion efficiency. The GaAs nanopillar structure additionally allows the construction of flexible solar cell arrays.

Their efficiency strongly depends on the understanding, characterization and modification of the pillars. The quality of the nanopillars is directly determined by the structure and the perfection of growth. Orientation measurements can provide the required information.

GaAs nanopillars were epitaxially grown on a GaAs substrate with a (111) B zincblende structure. The pillar morphology is directly related to the preferred growth direction: {111} top facet and six permutations of the {011} facets forming the hexagon side walls. The pillars vary in height from 500-700 nm and in diameter from 30 – 50 nm.

Previous investigations [1] proved the advantage of TEM studies on individual nanopillars and of EBSD investigations on the apex of the nanopillars. The present investigation was done in order to examine the crystal perfection along the growth axis of several GaAs nanopillars. Crystal growth is affected by structural defects which also degrade the electronic and optical properties of the nanopillars. The nanopillars were investigated for stacking faults, dislocations, and rotational twins forming in the growth direction. The presence of defects can locally change the orientation of the pillar towards the substrate.

For a measurement of the orientation along the pillars, the samples had to be mounted with the pillar axes orthogonal to the EBSD detector axis and the SEM column (fig 1). Fig. 2 shows the locations on a pillar where the EBSD patterns were collected. Ten pillars were analyzed for their orientations. The measurements were performed with a Jeol 7001 field emission electron microscope equipped with a Thermo Scientific NORAN System 7 and a QuasOr electron backscatter diffraction detector. Typical acquisition parameters were 20 kV at ~ 10nA.

The orientation of the nanopillars was the same as the wafer orientation with little if any change along up to 700 nm. With the exception of the apex of some pillars, the pillars had orientation differences less than the measurement uncertainty. Rotational twins could not be observed using EBSD, but from TEM investigations, it can be concluded that they are exhibited every 5 -10 nm.

EBSD has proven its capability to be used as a technique for measuring essential nanopillar properties. Compared to other techniques, EBSD yields results very quickly. This is an important aspect in the development of new materials for sustainable energy technologies.

References

Figure 1. EBSD linescan along a Ga As nanopillar

Figure 2. EBSD pattern of a GaAs Nanopillar, indexed as GaAs