13-Defects, Microstructures and Textures

The growth defects were imaged by using the X-ray topographic technique of A.R. LANG (CuKα radiation). They are mainly grown-in dislocations which originate from inclusions (gas bubbles) formed in the zone of first growth, in particular at the edges of the seed crystal. Other sources of dislocations are steps in the shoulder (cone) of the crystal boule. Such steps frequently appear when the diameter increase is too fast. The grown-in dislocation lines take a course roughly normal to the (local) growth front. Since this interface is (due to the air cooling mentioned above) concave against the melt, the dislocation lines do not grow out through the side faces, but are focused towards the axis of the crystal boule. This leads to an increase of the dislocation density along the axis of the boule. Nearly dislocation-free crystals can be obtained by careful control of the seeding-in procedure and the diameter increase.

In a few cases reactions of crossing dislocation lines have been observed. Dislocation lines with opposite Burgers vectors annihilate in the crossing region. Dislocations with different Burgers vectors b (e.g. b = [100] and [111]) form two nodes connected by a new dislocation line segment (b = [001]) of lower energy per unit length. The sum of Burgers vectors of the dislocations entering the node is zero (theorem of F. C. Frank, Bristol).


Salol, C₈H₁₀O₃, crystallizes in the orthorhombic space group Pnmb with lattice parameters a = 11.258 Å, b = 23.402 Å, c = 7.961 Å. The melting temperature is 42°C. Until now, single crystals have been grown from solutions and supercooled melts. These crystals exhibit a high growth anisotropy. They develop a plate-like habit with dominating (010) pinacoids.

In the present study, crystals were grown by the Czochralski method by pulling along various crystallographic and non-crystallographic directions. The aim was to study the growth behaviour and the typical arrangements of grown-in dislocations for different growth directions. The salol melt was held at about 0.5°C above the crystallization temperature at about 42°C. Due to the low thermal conductivity of salol and low heat radiation, an additional cooling of the growing crystal by the air circulating in the growth chamber was necessary. By decreasing the temperature of the cooling air from about 40 to about 35°C, the diameter of the crystal could be increased from 5 mm (seed crystal) to about 30 mm. Typical pulling and rotating rates were 0.6 mm/h and 8 rev./min. Crystals of up to 100 mm length and 30 mm diameter and of excellent optical perfection were obtained.

The crystals were cut into slices (thickness ca. 1 mm parallel to the pulling direction. Thus the slices contain a part of the seed crystal, the region of first growth on the seed, the crystal cone and the grown crystal until the end of growth. This allows to follow - within one specimen - the development of grown-in defects from the start to the end of the growth.

PS-13.02.12 X-RAY STRUCTURE DIAGNOSIS OF SEMICONDUCTOR MQW AND SUPERLATTICES. By Z. Ma*, C.F. Cui, J.H.Li and J.T. Ouyang, Institute of Physics, Chinese Academy of Sciences, Beijing 100080, China.

Semiconductor multi-quantum well (MQW) and superlattice (SL) systems are important materials for novel device applications. Recent studies have shown that the structural parameters and the perfection of the materials systems are the key factors to improve the physical properties of devices. AlₓGa₁₋ₓAs/GaAs MQW, GaₓAl₉₋ₓAs/AlₓGa₁₋ₓAs superlattices grown by MBE method were systematically investigated by x-ray double-crystal diffraction, x-ray grazing incidence diffraction and x-ray topographic methods.

Both coherent and incoherent interfaces between the two components of the GaₓAl₉₋ₓAs/AlₓGa₁₋ₓAs superlattices were observed. The experimental rocking curves of one sample having 15 periods shows that in addition to the substrate peak there is a family of periodic SL reflections due to the presence of a periodic strain in the epitaxial structure. Moreover, each satellite was accompanied by a set of interference fringes (Fig.1). By fitting computer-simulated double-crystal x-ray diffraction rocking curves to the experimental data, it is determined that there exist two types of crystals: (1) The thicknesses of the SL layers are the same, i.e. t = 8 Å and (2) t = 6 Å, the thickness of the GaₓAl₉₋ₓAs and the SL layers, respectively.

The structural parameters of 15 periods GaₓAl₉₋ₓAs/AlₓGa₁₋ₓAs strained layer superlattices were also determined by x-ray double-crystal diffraction.

<table>
<thead>
<tr>
<th>Table 1: Simulated parameters</th>
<th>N</th>
<th>t₁(Å)</th>
<th>t₂(Å)</th>
</tr>
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<tbody>
<tr>
<td>A 1-3</td>
<td>0.294</td>
<td>51</td>
<td>64</td>
</tr>
<tr>
<td>B 4-11</td>
<td>0.234</td>
<td>47</td>
<td>69</td>
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<tr>
<td>A 12-15</td>
<td>0.265</td>
<td>52</td>
<td>64</td>
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