Self-assembled Shape-controlled growth of crystalline Sb on Graphite

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We have investigated the growth of three-dimension (3D) spherical, 2D thin film and 1D nanorods of antimony on highly oriented pyrolytic graphite (HOPG) in ultra-high vacuum (UHV) using in situ scanning tunneling microscopy (STM). The shape and size of islands depend on a variety of growth parameters, i.e. flux, substrate temperature, deposition time, and layer thickness. Nucleation and growth of spherical 3D islands are dominant at low flux and room temperature. With a moderate flux, all three types of structures grow initially, but further deposition leads to mostly 2D and 1D crystalline islands at room temperature. The 3D and 2D structures of Sb on graphite have same bulk crystalline rhombohedral structure, but the 1D structure shows different crystalline structure from the bulk Sb lattice. At elevated temperature and higher flux, only the crystalline 2D and 1D islands were observed.

Experimental Details

- Cleave HOPG in atmosphere and degassed thoroughly at 700 K for 10 hours in UHV.
- Deposit Sb (mostly Sb4) on HOPG from W-boat evaporator at various conditions such as at different flux and substrate temperature.

Results and Discussion

Three types of Sb structures on HOPG: 3D, 2D and 1D islands

- At low flux and at RT: Exclusively 3D islands
- At high flux and at 100 °C: Only 2D & 1D structures formation

Summary of Crystal Structures of 3D, 2D and 1D

<table>
<thead>
<tr>
<th>Structure</th>
<th>Crystal Structure</th>
<th>Lateral period</th>
<th>Step height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Sb</td>
<td>Rhombohedral</td>
<td>4.31 Å</td>
<td>3.76 Å</td>
</tr>
<tr>
<td>3D Sb</td>
<td>Rhombohedral</td>
<td>4.32 ± 0.05 Å</td>
<td>-</td>
</tr>
<tr>
<td>2D Sb</td>
<td>Rhombohedral</td>
<td>4.32 ± 0.16 Å</td>
<td>3.76 ± 0.35 Å</td>
</tr>
<tr>
<td>1D Sb</td>
<td>Simple Cubic</td>
<td>4.15 ± 0.11 Å</td>
<td>3.67 ± 0.31 Å</td>
</tr>
</tbody>
</table>

Summary

- Spherical 3D, 2D thin film as well as 1D crystalline nanorods of Sb were observed on HOPG at different stages at RT.
- At T = 100 °C and a high flux, only 2D and 1D Sb islands were formed, whereas only 3D islands were obtained initially at low flux and at RT.
- The crystalline structures of 3D and 2D structures of Sb reveal same bulk crystalline structure, but the 1D nanorods shows simple cubic structure.