Metal-oxide nanostructures synthesized under microwave irradiation

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Introduction

The aim of environmentally friendly materials for multifunctional purposes and produced with low cost production routes is a reality nowadays. Chemical synthesis routes are known to be expensive and versatile, where the hydrothermal/solvothermal synthesis using conventional heating or more recently under microwave irradiation are interesting options for the production of high quality nanomaterials. Comparing conventional heating to microwave synthesis, the former is usually inefficient, time and energy consuming, while the latter has unique features such as short reaction time, enhanced reaction selectivity, energy saving, homogeneous volumetric heating and high reaction rate. In the present work, vanadium (VO2), tungsten (WO3), zinc (ZnO), zinc-tin (ZTO), copper (CuO and Cu2O) and titanium (TiO2) oxides were synthesized under microwave irradiation varying the synthesis parameters such as time, temperature, pressure, power input and solvent used. Several nanostructures such as spheres, stars, plates, whiskers, nanorods and nanowires were successfully synthesized [1,2], where these nanostructures were further structurally characterized by scanning electron microscopy (SEM) and employed in optoelectronic devices such as transistors, electrochromic and thermochromic devices, sensors, and as efficient photocatalysts.

Microwave Synthesis

- Microwave (MW) is a form of electromagnetic radiation with wavelengths from 1 m to 1 mm, and frequencies between 300 MHz and 300 GHz.
- Heating by: Dipole rotation: Polar molecules try to align themselves with the rapidly change of the MW electric field. This motion results in a transfer of energy.
- Ionic conduction: the electric field generates ionic motion in free ions as the molecules try to align themselves to the rapidly change field.
- Microwaves allows:
  - Selective heating
  - High heating rates
  - Short reaction time
  - Improved reproducibility
  - Pressure and temperature control

Power, time, pressure and temperature are the key parameters Solvent influences the final materials

<table>
<thead>
<tr>
<th>TiO2</th>
<th>ZnO</th>
<th>ZTO (Zn2SnO4)</th>
<th>VO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature = 80 °C</td>
<td>Temperature = 130 °C</td>
<td>Temperature = 180 °C</td>
<td>Temperature = 160 °C</td>
</tr>
<tr>
<td>Power = 100 W</td>
<td>Power = 100 W</td>
<td>Power = 250 W</td>
<td>Power = 250 W</td>
</tr>
<tr>
<td>Time = 1 h</td>
<td>Pressure = 50 Psi</td>
<td>Pressure = 270 Psi</td>
<td>Solvent: water</td>
</tr>
<tr>
<td>Pressure = 250 Psi</td>
<td>Solvent: water</td>
<td>Solvent: water</td>
<td>Solvent: water</td>
</tr>
</tbody>
</table>

Applications

- UV flexible photodetectors
- Nanotransistors
- Photocatalysis for water purification
- Sensors electrochemically active for bacteria detection
- Electrochromic devices
- Roof-type ceramic tiles - thermochromic materials

References


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