Composite Silicide Thermoelectric Materials for Power Generation

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TE Materials

TE - Si/Ge Alloys, Silicides, Ceramics
Temperature Range - 500 - 1000 °C
Environment - O₂, NO, CO, CO₂, H₂O

- Phonon Scattering
- Nano inclusions
- Alloyed Si/Ge matrix
- Mingo et al.
- 2-10 nm - optimum size
- WS₂ Best Silicide!

Directional Solidification

Melt - Solidification
Systems
YS₂, VS₂, TaSi₂, ZrSi₂, MoSi₂, Mg₂Si₂
TiSi₂, CrSi₂, MoSi₂, WS₂, CoSi

Advantages
- Stable High Temperature Interfaces
- Unique microstructures
- Cohesive Interfaces

Si-SiSi₂/(Si,Ge)-TiSi₂

Si-SiSi₂/(Si,Ge)-TiSi₂

Solidification Microstructures

Increasing Ge addition creates larger precipitates.
Ge segregation observed.
Melt Derived WSi₂-Si/Ge

Resistivity

Higher resistivity at 4-8% Ge
*Lower resistivity at 15-25% Ge

Seebeck

Higher Seebeck voltages at 4-8% Ge
*Lower Seebeck voltages at 15-25% Ge

Power Factor

Large power factors > nano Si/Ge
*High power factors at low temperatures
*High power factors at lower Ge content

Thermal Conductivity

*Si-MoSi₂ & Si-WSi₂-High k
*Ge important in reducing k
*Si-MoSi₂ more dependent on Ge content than Si-WSi₂
*Si-WSi₂ system gives ZT of 0.6

Furthermore reduction in k will enhance ZT

Spark Plasma Sintering

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>200-1000 °C</td>
</tr>
<tr>
<td>Heating/Cooling Rate</td>
<td>200 °C/min</td>
</tr>
<tr>
<td>Applied Pressure</td>
<td>70-80 MPa</td>
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<tr>
<td>Hold Time</td>
<td>~10 min</td>
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</tbody>
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Summary

- W, Mo & Ti systems gave high power factors (more than twice the nano-SiGe).
- W, Mo & Ti - large power factors at low temperatures.
- ZT = 0.55 for WSi2-SiGe eutectic is demonstrated.
- WSi2-SiGe - Potential higher ZT - reducing thermal conductivity
- SPS - Have not achieve good TE properties