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Precise synthesis of nano-sized TiB_2 for electronic applications

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Titanium diboride (TiB_2) is one of the hardest refractory material having very low electrical resistivity (10^{-6} Ω.cm) and high thermal conductivity (77-96 W. m^{-1}. K^{-1}) [1-2]. In addition to this TiB_2 has high oxidation resistance till 1200 °C and mostly inert to all the corrosive environment. These unique properties of TiB_2 have significant advantage in the military application (ballistic armors), cutting tools, crucibles etc.

TiB_2 can be synthesized by direct fusion method using titanium and boron compound but the temperature required is more than 1900 °C and in direct fusion process it is difficult to synthesize nano particle due to self-agglomeration of the TiB_2 particles [2-3]. To reduce the self-agglomeration and prepare nano particles of TiB_2; sol-gel and carbothermal reduction method has been used as an alternative. We have investigated the effect of citric acid as a capping agent and the ratio of B_4C: TTIP and ageing environment on the synthesis of TiB_2 nano particle.

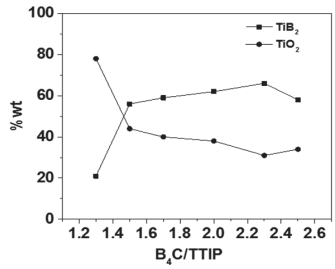

Figure 1: Effect of B_4C:TTIP %wt on the synthesis of TiB_2 via sol-gel and carbothermal reduction method at 1400 °C

It has been observed that at 1400 °C as the B_4C %wt increases formation of TiB_2 and also increases till B_4C/TTIP is near to 2.3. After the 2.3 %wt of B_4C to TTIP there is an increase in TiO_2 content due to heterogeneous hominization and improper gelation of $Ti(OH)_4$ due to excess B_4C surface area. There is also another possibility of the reduction reaction of TiO_2 by carbon from the boron carbide phase and its thermodynamical behavior, which has be observed and gives the clear indication of the TiO_2 content increase after %wt ratio of 2.3, as shown in Figure 1.

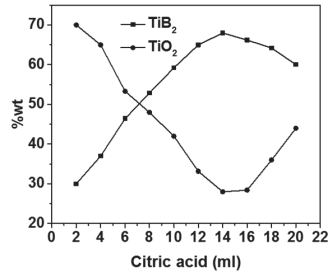

Figure 2: Effect of Citric acid on the synthesis of TiB_2 via sol-gel and carbothermal reduction method at 1400 °C

Citric acid also have some effect on the TiB_2 synthesis, as citric acid amount increases the capping of $Ti(OH)_4$ increases but excess citric acid reduces the overall reduction reaction of TiO_2 to TiB_2 due to thermodynamical imbalance, as can be seen in Figure 2. Finally, it has been observed that change in carbothermal reduction reaction temperature give rise to the change in the TiB_2 particle size. The optimum temperature to synthesize TiB_2 from TTIP and B_4C is 1450 °C.

The synthesized TiB_2 is highly thermal/electrical conductive, the density dependent transport properties such as thermal conductivity and electrical conductivity are studied to use TiB_2 as a nanoinclusion/contact material in the semiconductors.

References

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