Processing of delafossite $CuAlO_2$ ceramic targets by solid state synthesis route

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In the past two decades, a considerable effort has been devoted to the study and development of different n- and p-type oxide semiconductors for transparent electronics applications. The p-type delafossite materials $CuMO_2$ (M = Al, Cr or Y) with the band gap above 3 eV, which allows high transparency across the entire visible region, are of particular interest. Copper aluminate ($CuAlO_2$) films prepared by physical vapour deposition have been reported to exhibit the p-type behaviour and have already been used in various applications in optoelectronics. Phase-pure targets with a high relative density are prerequisites for physical vapour deposition of high quality $CuAlO_2$ films. However, secondary phases and low relative densities have been reported for the solid-state synthesized delafossite $CuAlO_2$ although high processing temperatures and extremely long times have been used [1, 2].

The aim of this work has been to prepare the phase pure delafossite powders and dense ceramics by solid-state synthesis. Instead of the usually reported α-alumina (α-Al_2O_3), we introduced the nano-sized boehmite μ-AlOOH.xH_2O powder as an aluminium source, for two reasons, i.e., for its high specific surface area and a consequent large number of contacts with Cu_2O particles and for higher reactivity as a consequence of the thermal decomposition (Hedvall effect) as compared to the oxide. Furthermore, the role of different atmospheres, namely inert (Ar) and oxidising (air), has been explored.

The solid-state reaction between nano-Al_2O_3 and Cu_2O (up to ≈ 1 μm in size) at 1100°C in argon resulted in the delafossite phase with appreciable quantities of both unreacted oxides even after 24 h of heating. In contrast, phase pure delafossite powder was synthesized upon heating the nano-boehmite and Cu_2O powder mixture for 2 x 10 h at 1100°C in inert Ar atmosphere as confirmed by XRD. The powder consisted of loose agglomerates of plate-like particles of a few 100 nm in size. Heating in air resulted in formation of the spinel $CuAl_2O_4$ and CuO phases beside the delafossite in both cases.

The ceramic with 86% of theoretical density has been obtained after sintering the boehmite-derived $CuAlO_2$ powder compact at 1100°C for 2h in air. According to XRD the ceramic was single-phase delafossite. However SEM /EDXS analysis revealed traces of Cu-rich impurities at the surface of the pellet. The bulk of the sample revealed a dense microstructure with a uniform distribution of porosity within the delafossite matrix.

References

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