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$MgZr_4P_6O_{24}$ conducting solid state electrolyte and its application in fabricating high temperature Mg sensors

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Novel Mg^{2+} conducting $MgZr_4(1-x)M_4xP_6O_{24}$ (x=0) multicomponent nanostructured ceramic oxide material synthesized by the sol-gel chemical process was first investigated by Ikeda et al. as a solid electrolyte which has been successfully utilized in fabricating CO_2 and SO_2 potentiometric gas sensors. However, this study depicts ceramic $MgZr_4P_6O_{24}$ synthesized and characterized for the fabrication of high-temperature electrochemical Mg-based sensors for the non- ferrous alloying, refining and process industries. Simultaneous TGA-DSC analysis provided insight into calcination temperature of the dried gel powders which was further analyzed through HTXRD measurements; where the determination of various phase changes at different measuring temperatures was achieved. Phase identification and structural analysis on the calcined nanopowders ($T \leq 900^oC$) and sintered pellets ($1000^oC \leq T \leq 1300^oC$) were analyzed by XRD, showing that both conditions depict high crystallinity and chemical stability. Using impedance spectroscopy measurement, the ionic conductivity of $7.23x10^{-3} Scm^{-1}$ at 725^oC was achieved in 2016 as a relatively higher conductivity compared to those determined earlier. Electrical properties on the platinized sintered $MgZr_4P_6O_{24}$ solid-state pellet was measured in the frequency range 100MHz-32MHz and a temperature range 30-800°C. The ac- and dc- conductivity measurement of $MgZr_4P_6O_{24}$ solid-state electrolyte depicts Arrhenius behavior with activation energies in the range $0.84 \leq Ea\ (eV) \leq 0.87$. The characterized solid-state electrolyte, $MgZr_4P_6O_{24}$ sintered pellet was successfully used in fabricating a solid-state Mg-based sensor using $MgCr_2O_4+Cr_2O_3$ biphasic powder mixture as a reference electrode. The bulk solid-state sensor was then used in measuring Mg in Molten Al at 700±5°C. The response of the Mg- sensor to changes in the concentration of Mg in molten Al at 700±5°C relates with the Nernst equation.

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