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MECHANICAL BEHAVIOR AND PROPERTIES OF $REPO_4$ STUDIED BY NANOINDENTATION

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Rare-earth orthophosphates ($REPO_4$s) have been used in experimental fiber matrix composites and are known to deform via a variety of mechanisms including dislocation motion, fracture, twinning, and pressure-induced phase transformations. $REPO_4$ with RE in the range of Z=64-66 (Gd-Dy) are particularly interesting due to their proclivity for polymorphism and phase transformation. To date, the behavior of these materials has been briefly studied using nanoindentation; however, detailed analysis of the indentation curves is made difficult due to the large number of potential deformation mechanisms. This study analyzes the behavior of nanoindentation load-depth curves and mechanical properties collected from $GdPO_4$, $DyPO_4$, and solid solutions of the two in order to elucidate the physical phenomena responsible for the indentation behavior. Composition, strain rate, and maximum indentation load are systematically varied. Typical nanoindentation curves show discontinuous behavior including pop-ins, dramatic changes in the unloading slope, and pop-outs. It is found that in all of the materials, pop-ins were ubiquitous, while pop-outs were much more rare— occurring only in the solid solutions. Dramatic changes in unloading slope are frequently observed in all compositions, and have been associated with phase transformation and/or twinning in other material systems. Mechanical properties are reported for each of the compositions as a function of maximum indentation load and the influence of certain discontinuous load-depth behaviors on those measurements is discussed.