Particulate composites are widely used in many aerospace and military applications as energetic materials, armor materials or coatings and their behavior under dynamic loads have gained increasing significance. The addition of modifiers such as alumina nanoparticles generally facilitates the improvement of the mechanical strength to density ratio due to high specific area and particle rigidity. This allows for sufficient particle-matrix bonding and therefore improved stiffness and load transfer in the composite. Photo-luminescent $\alpha$-alumina nanoparticles when embedded in an epoxy matrix allow for the added benefit of in situ measurements at low strain rates to provide stress-sensitive information using the particle piezospectroscopic (PS) property. To investigate the low strain rate behavior, cylindrical specimens of alumina epoxy composites with varying volume fractions of alumina were fabricated using a casting process to ensure minimal surface finishing and reduced manufacturing time. The results illustrate the capability of alumina nanoparticles to act as diagnostic sensors to measure the stress-induced shifts of the spectral R-line peaks resulting from low compressive strain rates. The range of PS coefficients measured, 2.21 to 4.64 cm$^{-1}$/GPa, correlate well with static test results of similar volume fractions. Results reveal a general trend of increasing sensitivity of the PS coefficients with increasing strain rate when compared to similar materials under static conditions. In contrast to static results, at a given strain rate, the PS coefficients show varying degrees of sensitivity for each volume fraction. This information can be used to determine the time-dependent micro-scale stresses the nanoparticles sustain during composite yielding and failure. Additionally, this work facilitates failure prediction by monitoring upshifts in the PS information. Calibration of the in situ diagnostic stress sensing capabilities of varying volume fractions of alumina nanocomposites under quasi-static strain rates in this work sets the precedent for future studies at high strain rates.

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The public is welcome to attend.