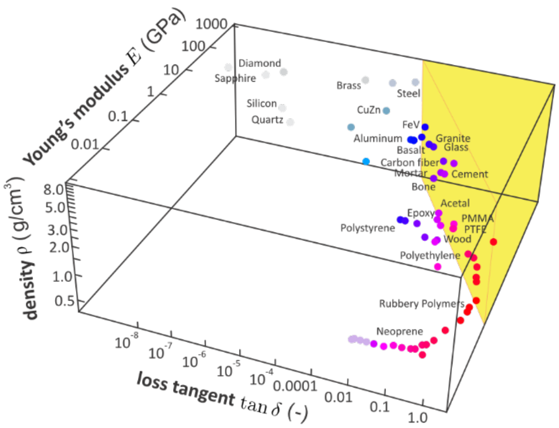
Taking Advantage of Ferroelectric Instabilities for Creating High Stiffness, High Damping Materials

Charles S. (Stan) Wojnar
Assistant Professor, Mechanical and Aerospace Engineering
Missouri University of Science and Technology



The combination of high stiffness and high damping properties in materials enables the utilization of load carrying components of structures to act in the additional capacity as mechanical dampers. However, this combination of properties will quickly elude the design engineer. Indeed, common engineering materials possess either high stiffness or high damping but not both. For example, ceramics exhibit a high stiffness and low damping whereas rubbers exhibit low stiffness and high damping. To solve this problem, we must turn to different internal mechanisms in materials that cause damping (beyond e.g. defect motion in metals and ceramics or the motion of molecules in polymers). One such mechanism is instability through e.g. phase transformations. Temperature-induced phase transformations in solids would be difficult to control in practical applications. Therefore, in this work, we turn to electric field-induced structural transformations in ferroelectrics, viz. domain switching. In this process, regions of differently-oriented polarization of the underlying crystal (or grain) are reoriented at the microstructural level by an externally-applied electric field; turning on the dissipation mechanism in the material is controlled by the push of a button. Domain switching leads to a substantial increase in the overall damping capacity of the material. Recent experiments have measured a mechanical loss tangent during domain switching in ferroelectric ceramics of approximately 0.4. Such a value of the loss tangent are normally reserved for polymers, not stiff ceramics. Thus, the combination of high stiffness and high damping was observed.

Bio: Dr. Charles S. Wojnar recently started as an Assistant Professor at Missouri S&T in the fall of 2015. He received his MS and PhD in Aeronautics from the California Institute of Technology in 2011 and 2015, respectively, after obtaining a B.S. in Aerospace Engineering from the University of Illinois at Urbana-Champaign in 2010. Dr. Wojnar's research interests lay at the intersection of mechanics, materials science, and manufacturing. His research group conducts basic and applied research on ways of designing materials and structures through different manufacturing processes to obtain desired macroscopic properties included improved viscoelastic properties, fracture toughness, and electromechanical actuation.