**TITLE:** The Behavior of Bulk Powder Flow under Mechanical Vibration and its Effect on the Mechanics of Auto-Granulation

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**ABSTRACT:** Particle level correlations that have guided product structure-property outcomes in advanced processing and manufacturing technologies for glass and ceramic processes are well established. The influence of bulk powder effects (powder as used) on structure-property functions, however, remains elusive. Bulk powder effects depend on the ensemble of particles packing and require a multi-scale evaluation, which includes the meso-scale (particle ensemble level) to bridge nano/micro particle scale characteristics and bulk powder macro-scale behavior. Fine particle (<100 microns) powder flow can exhibit cohesive behavior resulting in poor flowability, affecting agglomeration formation as well as powder caking, all of which can be detrimental to the processing and/or final product structure-property outcomes. For this reason, bulk powder characterization (dynamic and quasi dynamic) can be used to identify causal effects. In this study, the bulk behavior of powders is observed under a simple powder process: harmonic, mechanical vibration. Four powder samples, two alumina and two titania powders, were studied. The main difference between the two powder variants of each material is their primary particle size. The two alumina (Al2O3) powder samples had a median primary particle size at 50 percent less than (d50) of 0.5 and 2.3 μm and the titania (TiO2) powder samples had a d50 primary particle size of 0.1 and 1 μm.

As vibrated, the titania powder variant with a primary particle size of 0.1 μm exhibited a clustering behavior known as auto-granulation. Auto-granulation is the growth of particle clusters within a dry, fine powder bed without the addition of any binder or liquid to the system. The amplitude and frequency of the mechanical vibration was varied to view the effect on the equilibrium granule size and density. Furthermore, imaging of cross-sections of the granules was conducted to provide insight into to the internal microstructure and measure the packing fraction of the constituent particles. As this auto-granulation behavior was unique to only one of the powder variants, an investigation was made into the differences in the powder fundamentals of the variants to identify the critical properties influencing the bulk powder behavior. Links were then created between the measured powder properties to the observed, bulk dynamic behavior under vibration in an effort to understand the mechanics occurring within the powder bed. By creating these correlations, an advanced understanding of powder behavior was attained for all powders studied. The study covered extensive characterization of the bulk powder properties. These properties ranged from micro-scale, discrete static particle characteristics to viewing the bulk powder as a continuum material providing new insight into the micro and meso-scale linkages to better understanding of cohesive bulk powder behavior to help guide improved structure-property outcomes in ceramic and glass processes.

**PRESENTER’S BIO:** Dr. Murtagh is the technical director of Corning Incorporated’s exploratory particle and powder technology platform in the department of Characterization Sciences, in the Science & Technology Division at Corning Incorporated, Corning, NY. In addition to his work at Corning, He is an Adjunct Professor of Material Science & Engineering at Cornell University; Ithaca, NY teaching materials enabled design concepts. He is a Visiting Professor of Material Science and Engineering at the University of Leeds, UK with teaching and research advising responsibilities in the College of Chemical Engineering’s Particle Science and Engineering Institute. He hold 15 United States and European patents in the area of automotive and diesel pollution abatement and particle and powder technology, and is the co-author of several papers in the field of Material Science. He earned a B.A. in Fine Arts and a B.A. in Geology from Hartwick College, M.Sc. in Ceramic Science from Pennsylvania State University, and a M.Sc. and Ph.D. in Material Science and Engineering from Cornell University.