Characterizing X-ray computed tomography phantoms for reliability analysis

Felix (Hoyean) Kim[1], John Henry Scott[2], Mark McLean[2], Edward Garboczi[3], Adam Pintar[4], Sarah Robinson[5], Nikolai Klimov[6]

[1]Intelligent Systems Division, National Institute of Standards and Technology, USA, [1]Materials Measurement Science Division, National Institute of Standards and Technology, USA, [1]Applied Chemicals and Materials Division, National Institute of Standards and Technology, USA, [1]Statistical Engineering Division, National Institute of Standards and Technology, USA, [1]Sensor science division, National Institute of Standards and Technology, USA, [1]Sensor Science Division, National Institute of Standards and Technology, USA

X-ray computed tomography (XCT) is a promising non-destructive testing (NDT) method for advanced manufacturing industry including additive manufacturing (AM). Assessment of NDT reliability is a crucial element of manufactured part qualification where quantitative evaluation results such as probability of detection (POD) are needed. Phantoms with representative flaws need to be fabrication for such reliability analysis, but there remain some challenges associated with developing phantoms with various representative flaws suited for XCT measurements. NIST is investigating various approaches to developing such phantoms including the method of stepper lithography with deep reactive ion etching (DRIE) on Si substrates, and we will present the progress of developing the phantoms. The advantages and challenges of encapsulating artificial pores through chip or wafer bonding approach will be discussed. We will additionally present different approaches to characterizing the true flaw sizes using electron microscopy and optical methods and compare the measurement results for repeatability and reproducibility. Based on the characterized flaw sizes, we will demonstrate different reliability analyses such as POD and pore size calibration. Different image segmentation algorithms and their parameters were applied and compared for accuracy. Augmentation of realistic XCT simulation is being explored, and the simulation results will be compared to experimental results.