X-ray Computed Tomography for Materials Science

S&T Campaign: Materials Research
Manufacturing Science

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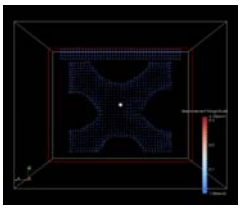
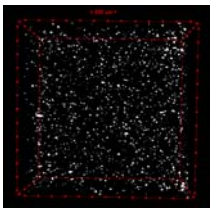
Research Objective

- **Utilize advanced 3D imaging and data analysis capabilities to discover and understand processing-microstructure-property relationships**
- **Utilize computational simulations and *in-situ* mechanical testing to explore material behavioral mechanisms**

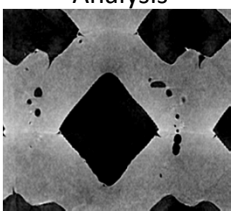
Computational simulations



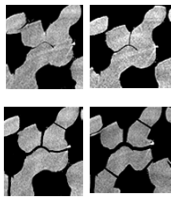
Particle size distribution



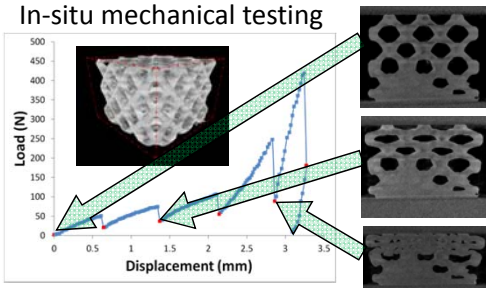
Defect/Porosity Analysis



Crack propagation and failure



In-situ mechanical testing



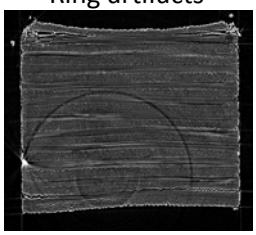
ARL Facilities and Capabilities Available to Support Collaborative Research

- **Bruker Skyscan 1172**
  - **0.5 um voxel size**
  - **20-100 kV**
- **Zeiss Xradia 520**
  - **70 nm voxel size**
  - **30-160 kV**
  - **Phase contrast enhanced imaging**
- **225/450 kV System**
- **In-situ mechanical testing**
- **Data analysis software**
- **Computational modeling and finite element analysis**
- **ARL CT expertise includes a wide range of materials:**
  - **Composites (UHMWPE, Carbon fiber, Glass fiber)**
  - **Ceramics (B_4C, Al_2O_3, SiC)**
  - **Metals (Aluminum and metallic coatings)**
  - **Polymers (PC, ABS, polyurethane foams)**
  - **Bio-materials (trabecular bone)**
  - **Multi-material and hybridized structures (concrete, metal-ceramic interfaces)**

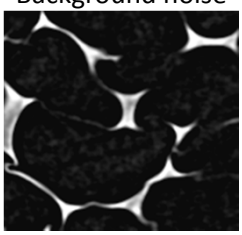
Challenges

- **Resolution limitations, x-ray penetrating power, contrast between similar attenuating phases, and scanning artifacts are known challenges for computed tomography**
- **Most scanning artifacts, however, can be eliminated or significantly reduced with optimized scanning parameters or artifact corrections during the reconstruction process**

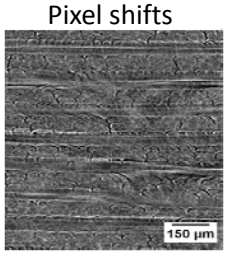
Ring artifacts



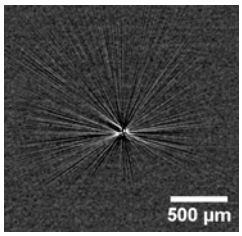
Background noise



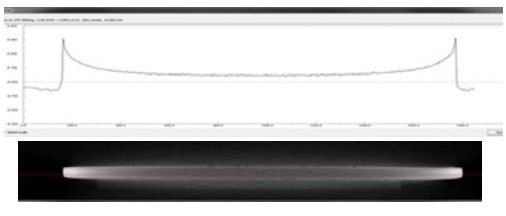
Pixel shifts

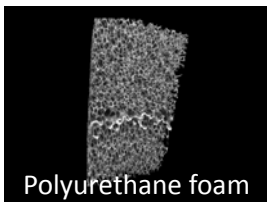


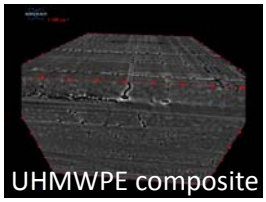
Streaking

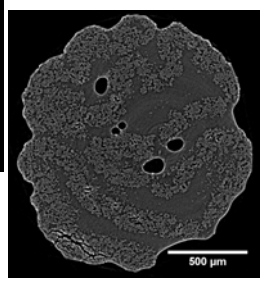


Beam hardening

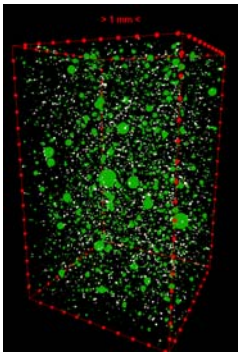








Carbon fiber composite



Isolated air (green) and silica (white)

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Advanced data analytics**
- **Digital volume correlation for in-situ mechanical testing**
- **Complementary microscopy facilities not available at ARL**
- **Unique material processing or mechanical testing capabilities that would be used collaboratively to establish processing-microstructure or microstructure-property relationships**

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