Modeling CMC Microstructures Using Segmented Fiber Data

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Integrity ★ Service ★ Excellence

MOTIVATION

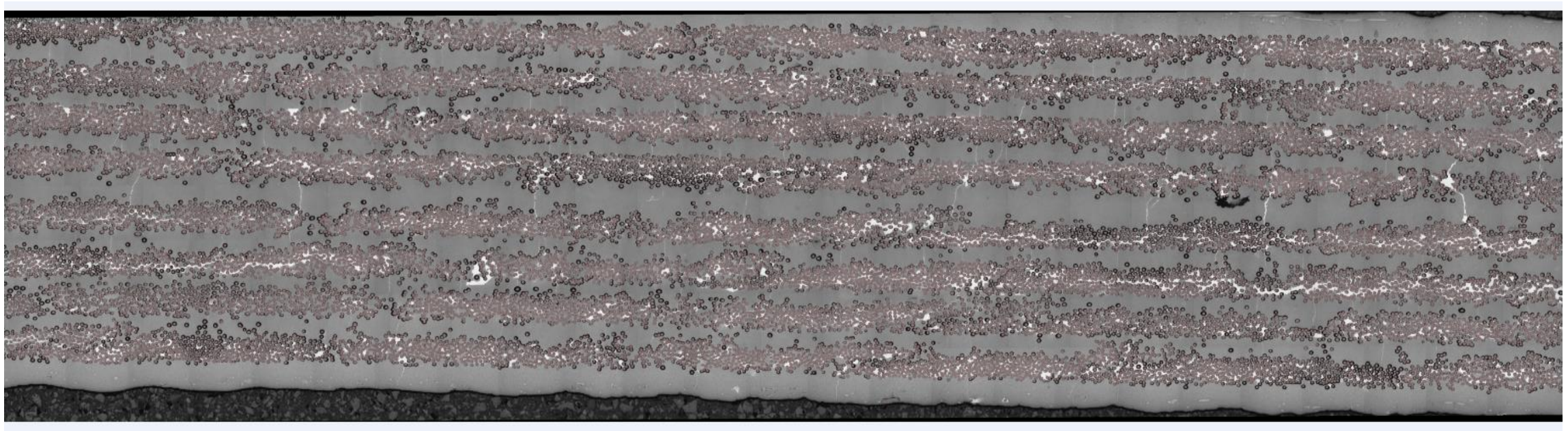
- **Desire to better understand microstructure and its effects on material properties at macro scale**
- **Quantify structure properties that induce and drive damage within microstructures**
- **Create a database of reoccurring micro structures with high damage probabilities**

Difficulties

- Combining coatings and separation of clusters in BSAM
- Accurate and robust surface selection algorithm
- Proper mesh seeding/size
- Optimization with respect to time

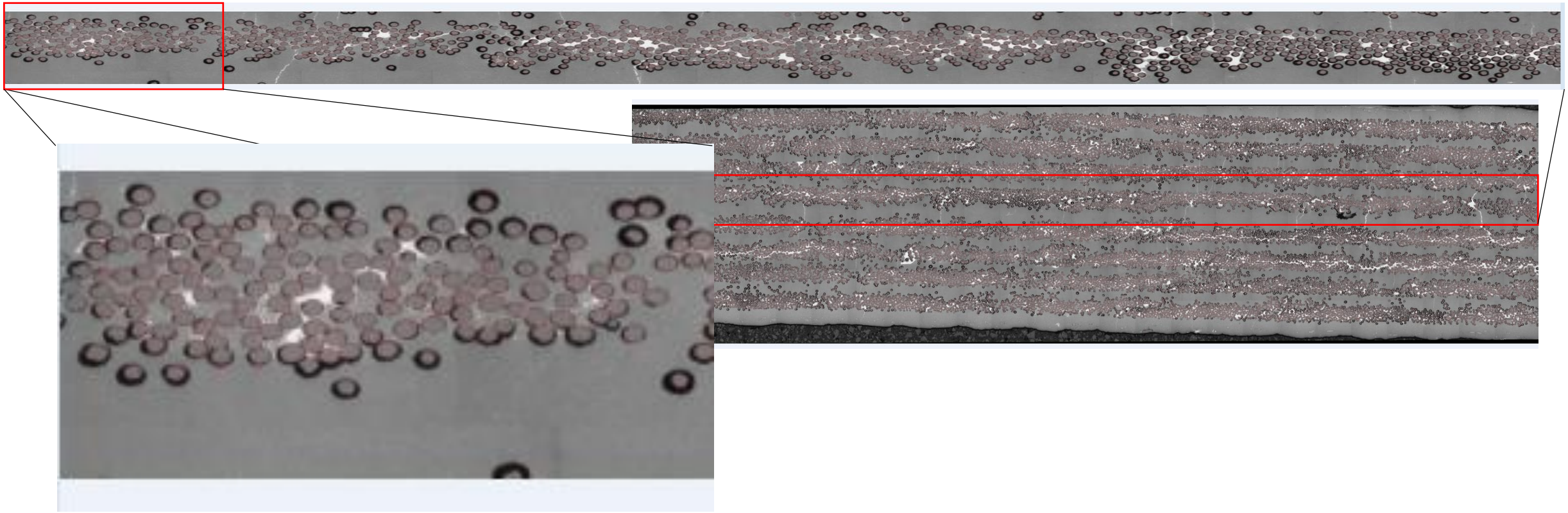
BACKGROUND

- Matlab script that gives geometric fiber data (i.E. X- and y-coordinates, major and minor axis, angle of rotation, etc.) From fiber-matrix scan
- Need to produce a model that can be executed using BSAM



SEGMENTATION AND DIVISION

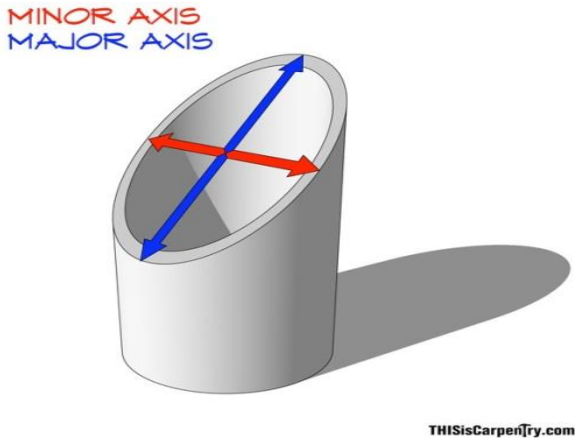
- Analyze one layer at a time, using Matlab script to identify and describe fibers
- Data is then divided into sub-sections using a separate Matlab script file



MODELING

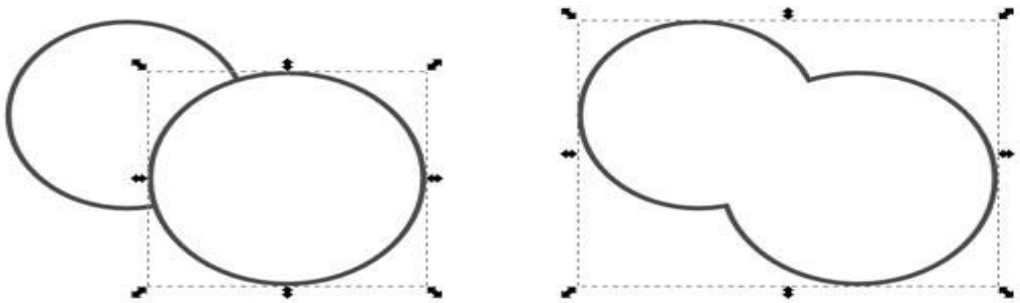
Start with coordinates and radius of each fiber (idealized model)

- Data given in elliptical format, for now we assume idealized circles
- Assumption is due to image given has angled fiber orientation, therefore radius should be minor axis of fibers given



Using Abaqus with a Python script file, coatings are added and combined

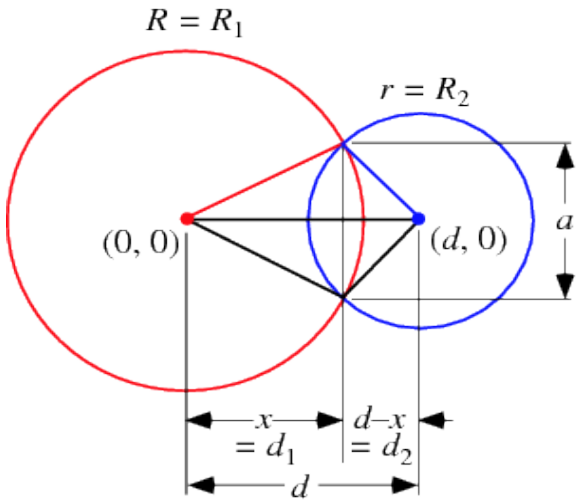
- Difficulties arise for combining coatings
- Discussion in next slide



COMBINING COATINGS

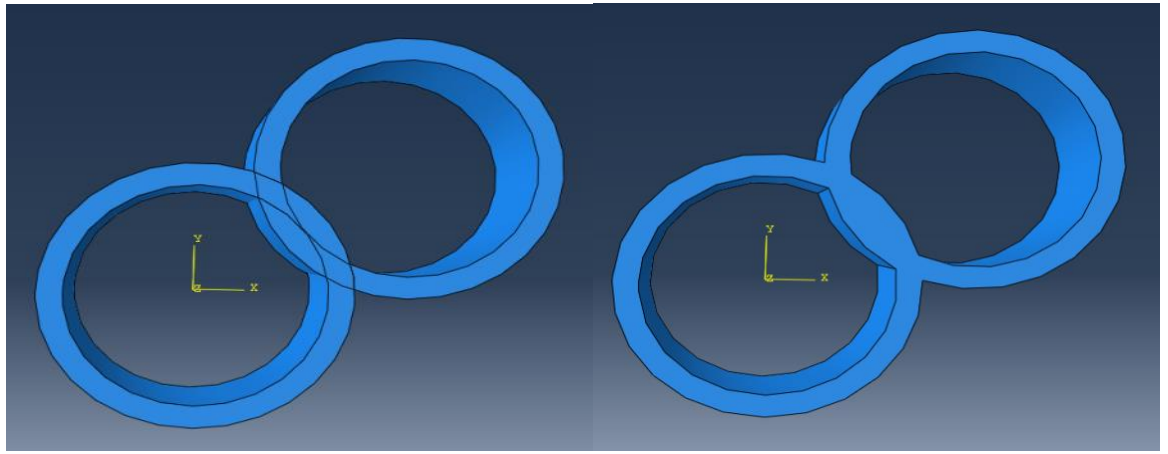
Single cluster for all coatings

- Combine geometries at sketch level
- Using circle intersection formula to find intersection points and create arcs



Single cluster per coating

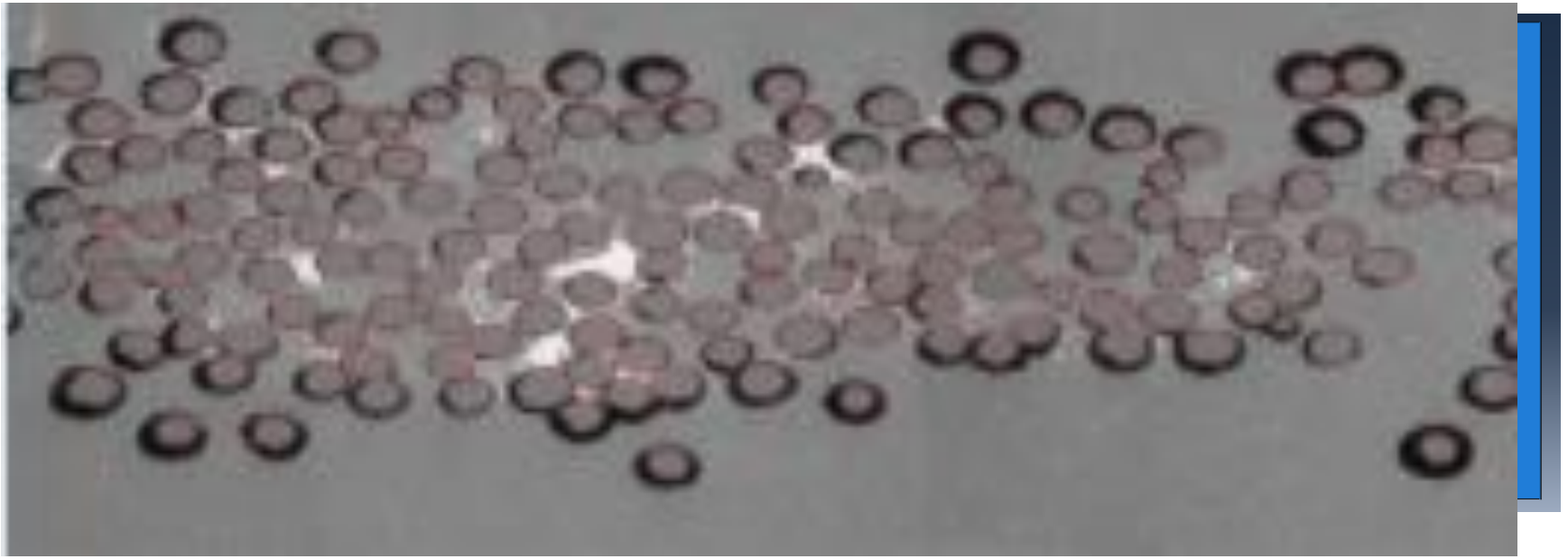
- Combine geometries at the part level
- Simple Boolean command in Abaqus with renaming of part instance



MODELING (CONT'D)

An assembly is created to mesh

- Matrix template is created and is then cut by fiber and coatings
- Assembly is then created by inserting part instances into the assembly for meshing
- Complex geometries require mesh refinement around intersections



MODELING

Start with coordinates and radius of each fiber (idealized model)

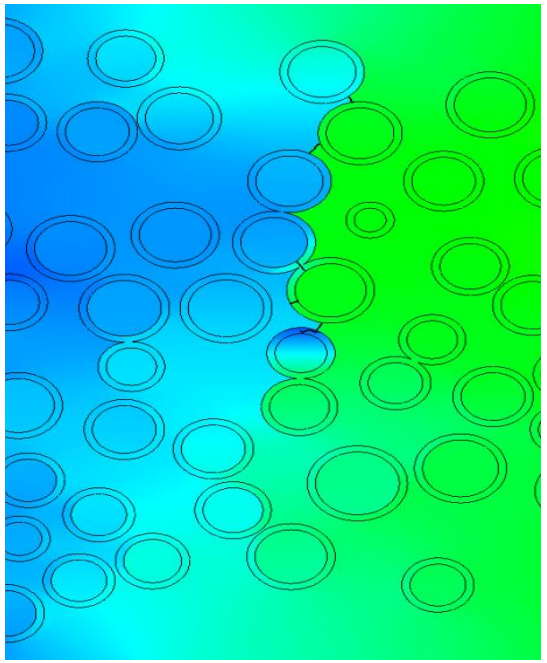
- Assume radius is the minor axis, eccentricity to be added later
- Fibers are not allowed to overlap

Using Abaqus with a Python script file, coatings are added and combined

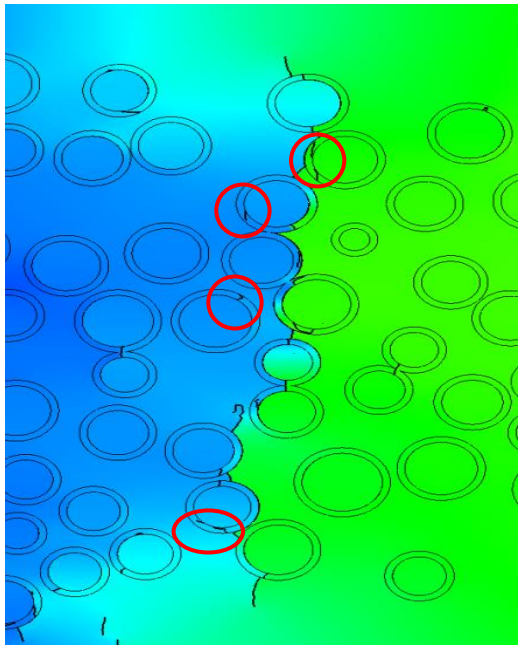
- Coatings as a single cluster leads to suppression of crack insertion
- Later changed to separate clusters for crack initiation

An assembly is created to mesh

- Refinement of seed to ensure matrix meshing and mesh compatibility



Single cluster for all coatings

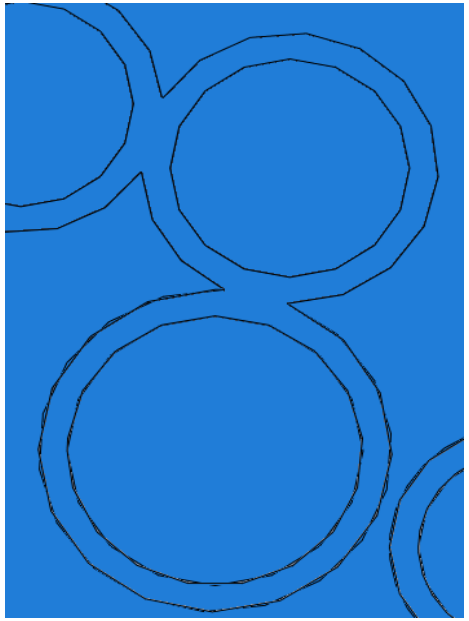


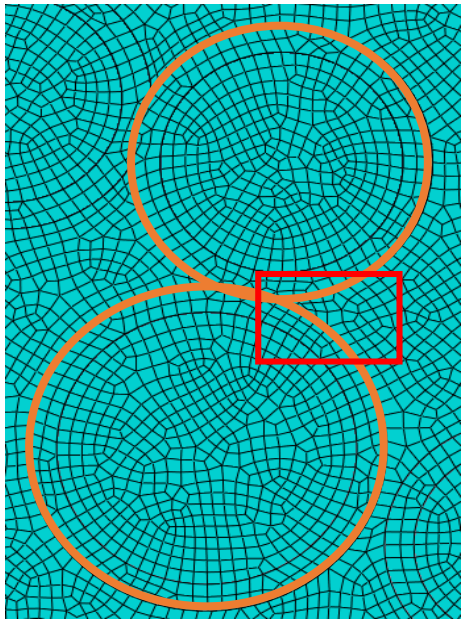
Individual cluster for each coating

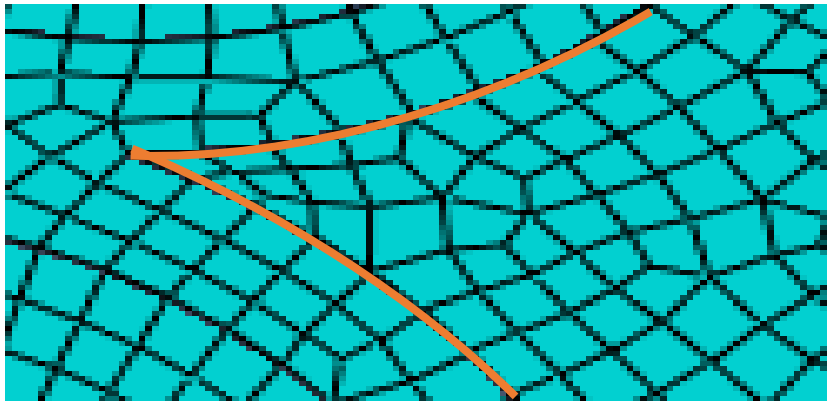
MESHING GEOMETRIES

Complex geometries require mesh refinement around intersections

- Sharp points are created from intersection of coatings
- High refinement needed in this area to mesh without error
- Will look for better refinement options in the future



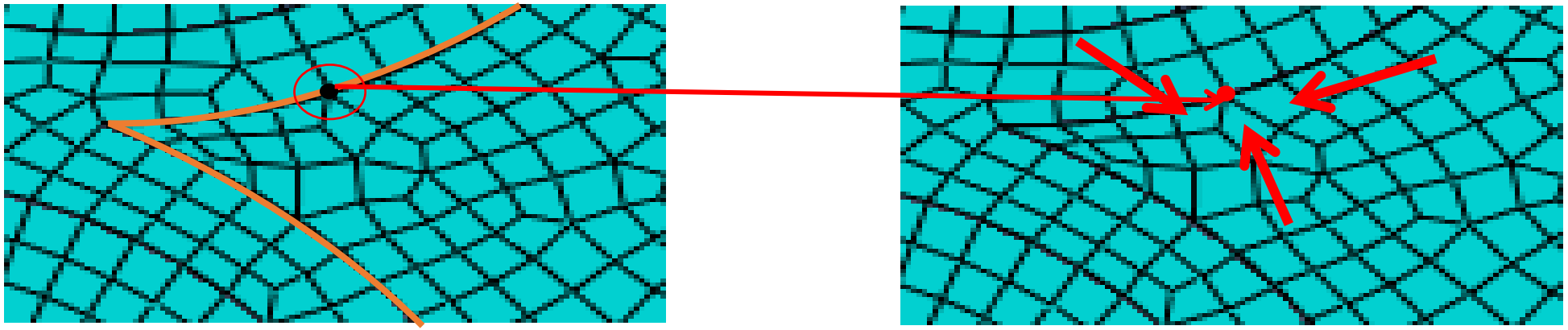




SURFACE SELECTION

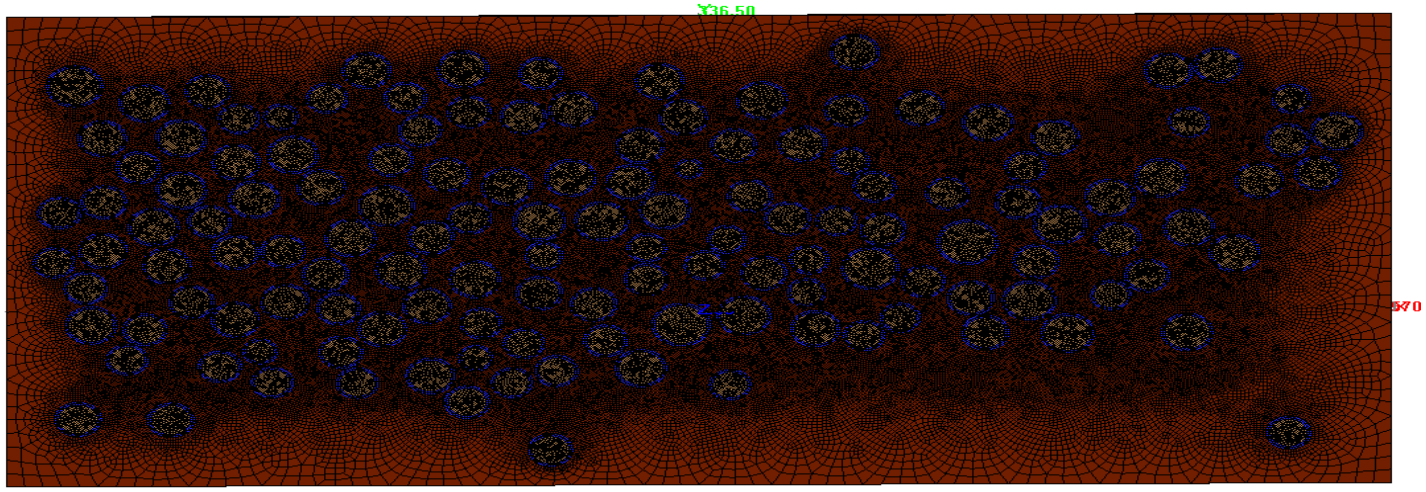
In order to use BSAM connection properties for interfaces, connecting surfaces must be found

- Use bounding cylinder around coating node to select nodes in matrix that correlate to nodes on each coating
- Take found nodes and determine connecting elements
- Save found elements for connection element sets in BSAM



MODELING (CONT'D)

- Resulting mesh is saved in Abaqus
- In order to use BSAM connection properties for interfaces, connecting surfaces must be found
- Surface selection is much more difficult for individual coatings



INPUT AND ANALYSIS

Once connections are established, an input file is created and then run using BSAM

- File includes output for loading along boundary conditions for load-displacement curves
- Allows for Mesh Independent cracking along with separation between interfaces
- Looking for modes of damage propagation

CURRENTLY

Reworking selection algorithms for efficiency and speed

- Implementation of advanced searching algorithms and rewrite of output portion of script

Modifying surface selection for robustness

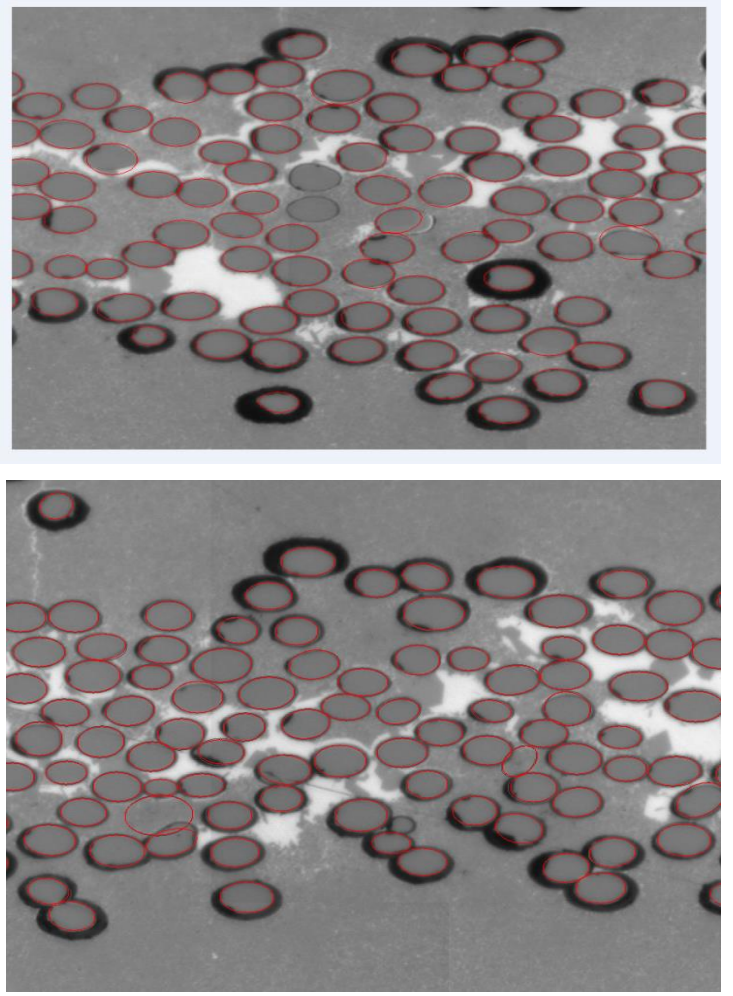
- Additional consideration for fiber connection orientations and patterns

Finalizing modifiable parameters and callable arguments

- Includes thickness, separation factor for fibers, and mesh seed value

FUTURE TASKS

- Further improve fiber identification method and speed of model creation further
- Collect numerical data from simulations and being quantitative characterization
- Add ability to have eccentricities in coatings, fiber shape, and possible void insertion
- Create macro to fully compile models for all sub-sections in a given picture larger than one layer



Questions?