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# Multiscale Modeling

Grain Growth Cellular Automata Project

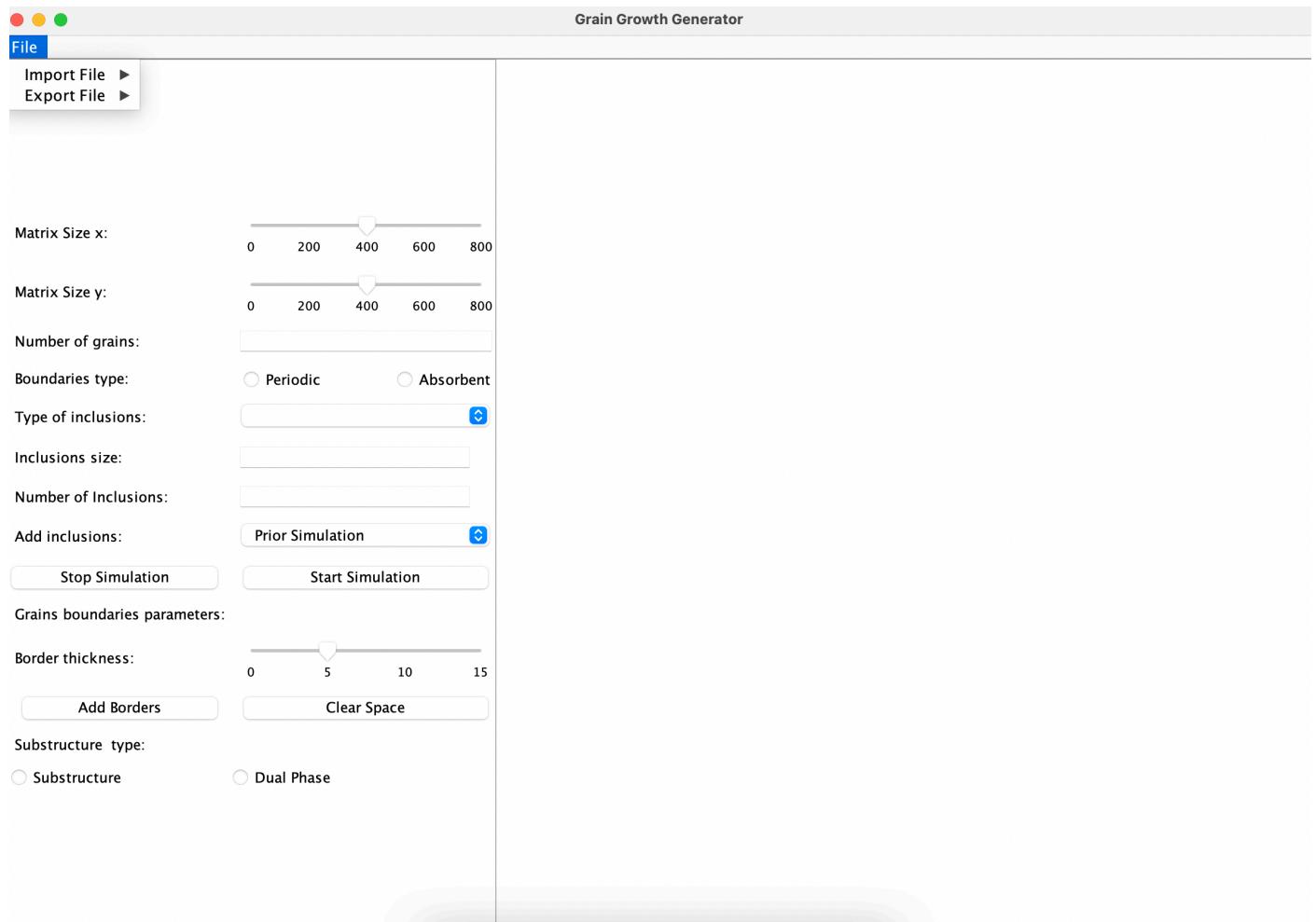
## 1. Model implementation details

The project is written in Java using Swing Library. The logic in App is held via Arrays and Arrays List. The drawings during simulation are populated by paint() method od Canvas Component one the basis od Model Output Array. The simulation redraw updated output Array. The simulation results can be exported in two formats, the import also works for both.

The application uses the Cellular Automata in order to populate the grains growth.

## 2. GUI presentation and its functionalities

The GUI allows the user to choose different model parameters. User can set following functionalities:

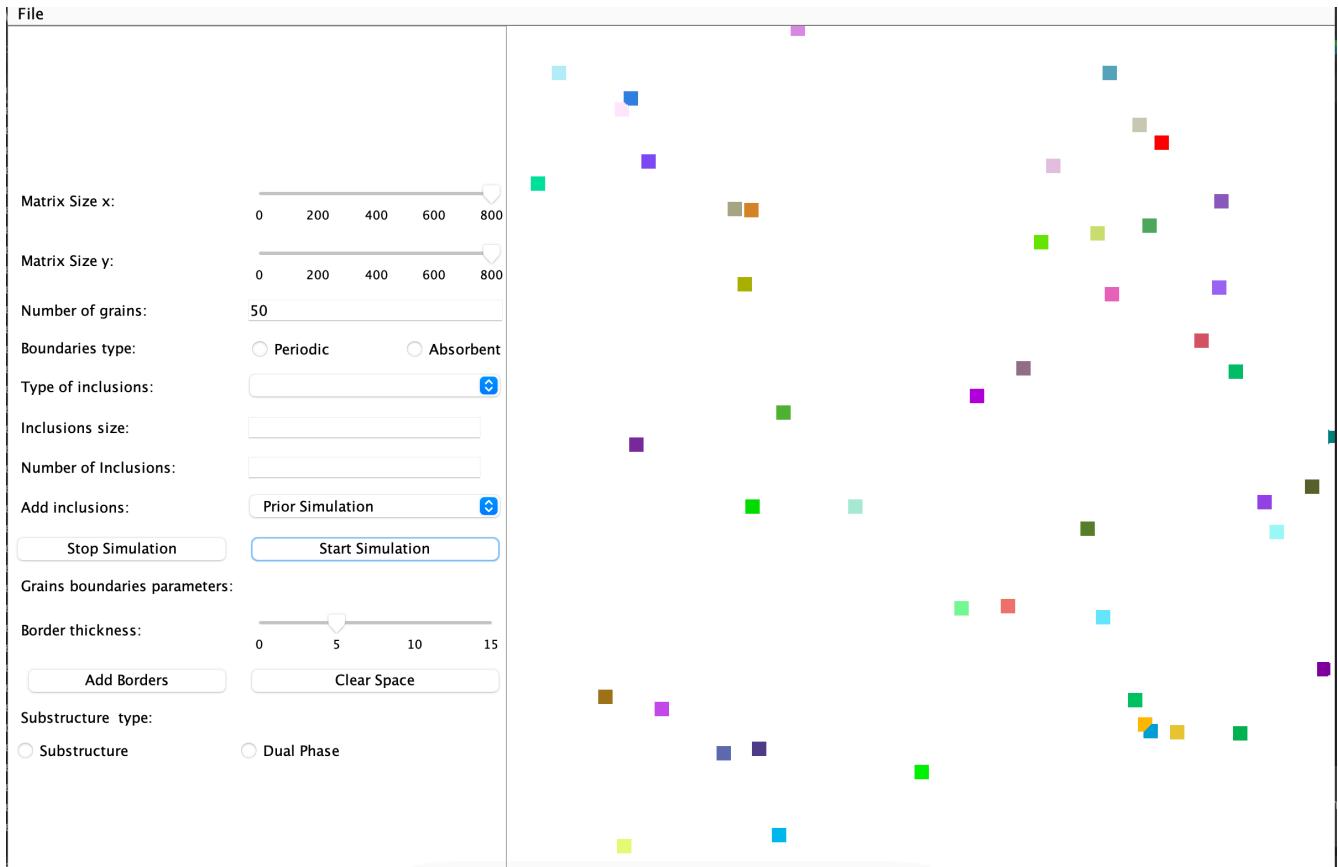


Picture 1. GUI presentation  
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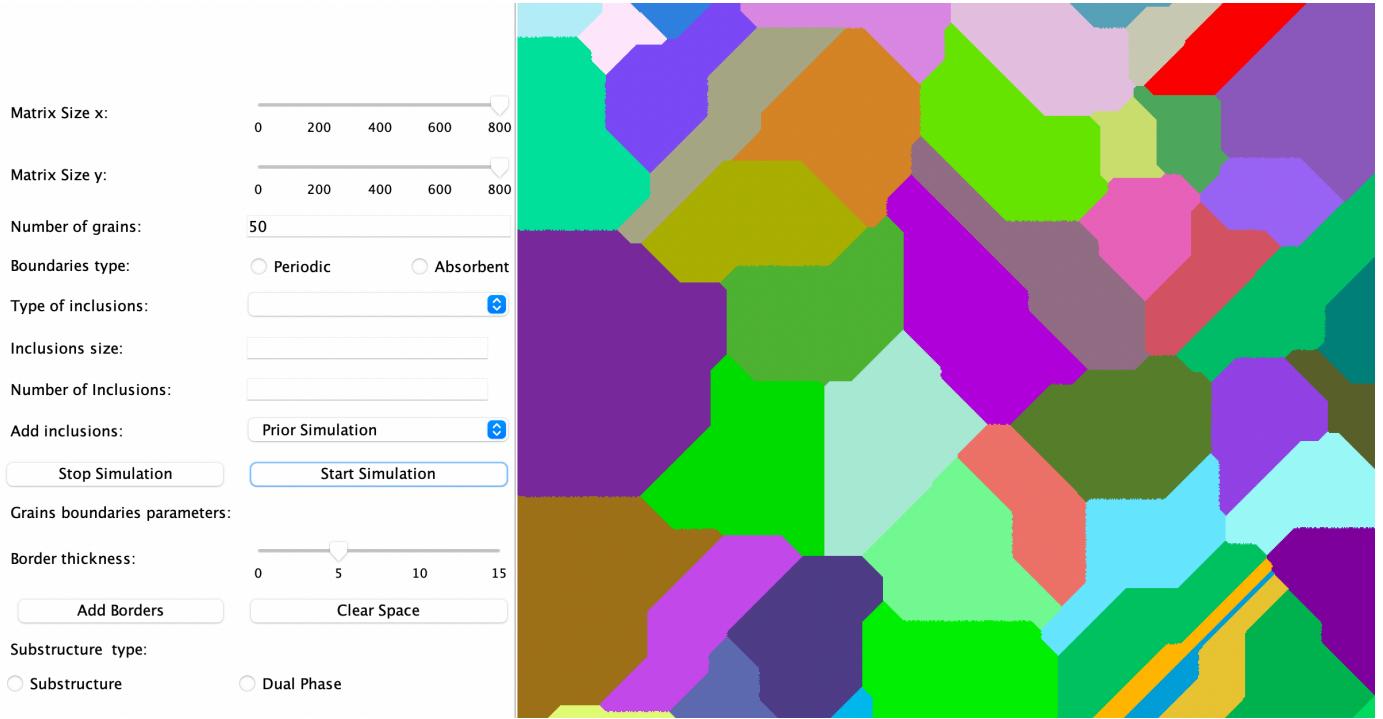
- i. User can set the size of Matrix where simulation will be executed. Maximum size of the Matrix is 800. The size of the Java Component where simulation is painted is 800px x 800px. The application adjust the painting area on the basis of Matrix Size and Maximum Canvas size, so the image is always as big as possible.
- ii. User always must determine the number of seeds
- iii. If needed user can choose between two Types of Inclusions size: square, circular. None is also an option.
- iv. If Type of Inclusions value is selected, user must determine Inclusions Size and Number of Inclusions
- v. User can also determine time of inclusions adding: prior simulation or post simulation
- vi. After clicking into Start Simulation Button, the simulation starts.
- vii. After grading growth is complete, user can also draw border for all grains after clicking onto Add Borders Button
- viii. After grain growth is complete, and borders are painted, user can clear the picture in order to nothing but borders.
- ix. Another functionality of the app is painting borders around selected grains on the screen. User can also use Clear Button in order to clear the picture and see nothing but selected grains boundaries.
- x. After simulation user can choose also Dual Phase Radio Button in order to paint black selected grains in the picture.
- xi. After simulation user can choose also Sub Structure Radio Button in order to proceed Grain Growth in Selected Seed. The numer of inner seeds is always 7.
- xii. Files can be imported and exported via .txt and .bmp files format

### 3. Model setups and results

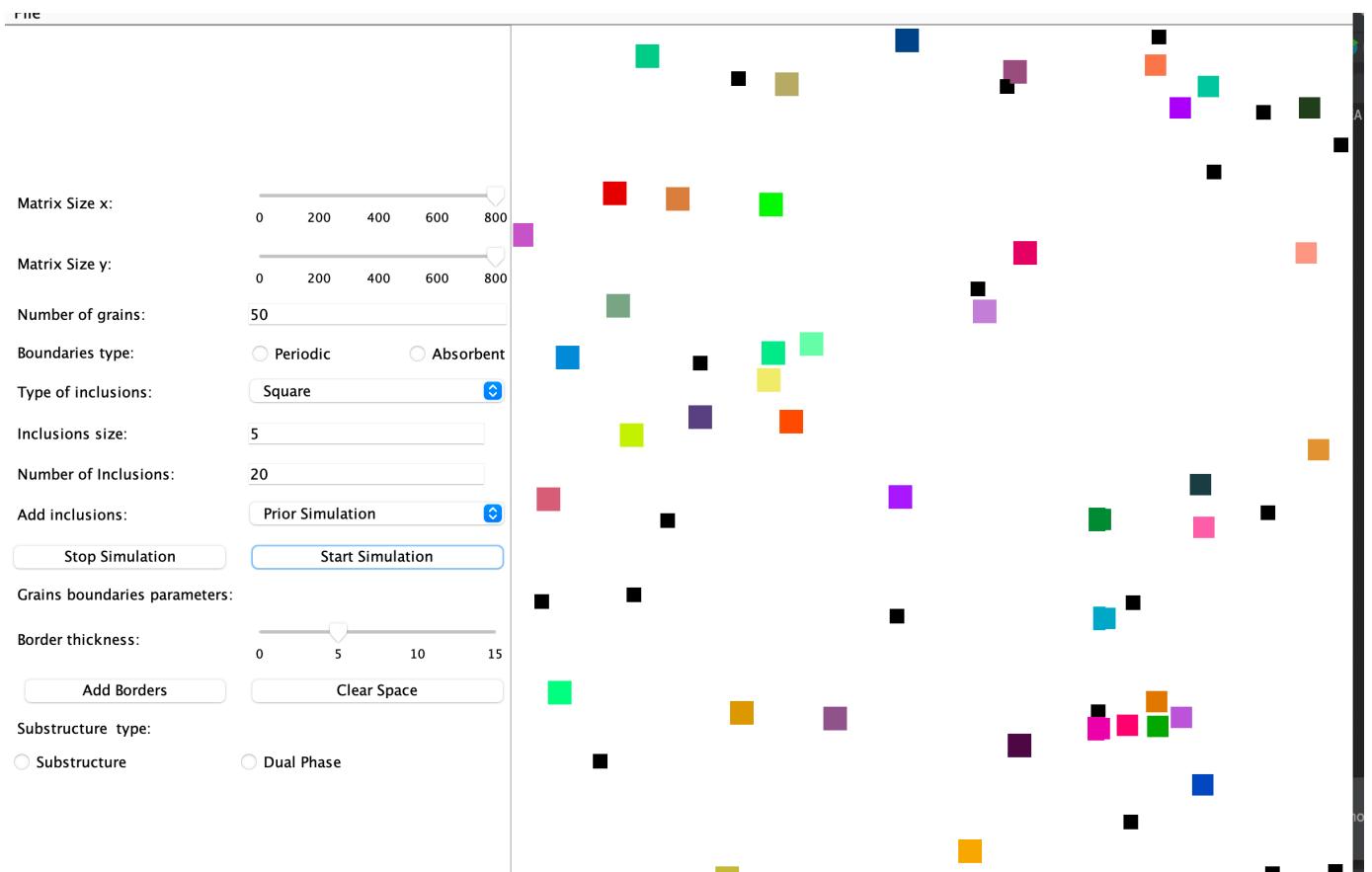
#### 3.1 Simple Grain Growth simulation



Picture 2. One of the first steps of simple Grain Growth Simulation for following parameters: Matrix Size X and Y = 800, Number od Seeds 50

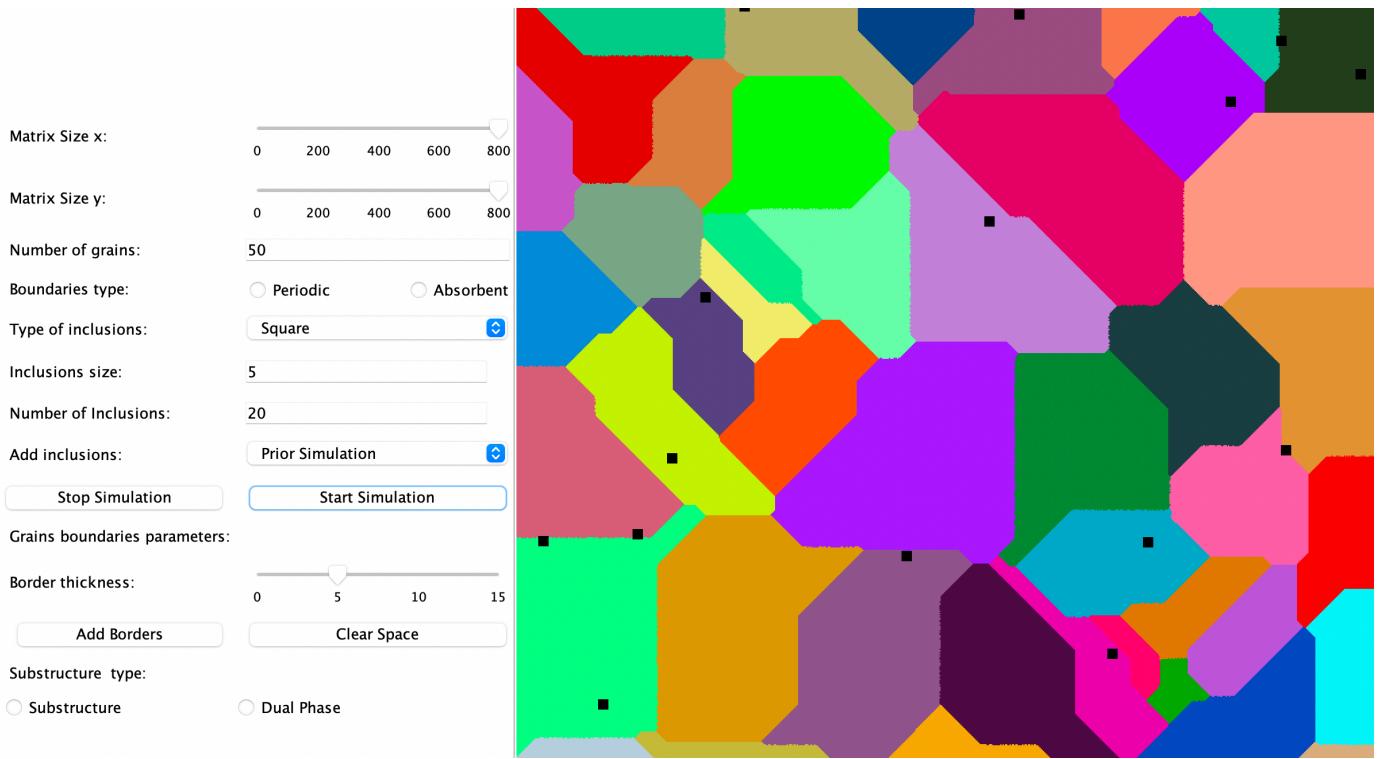


Picture 3. Last step of simulation above.



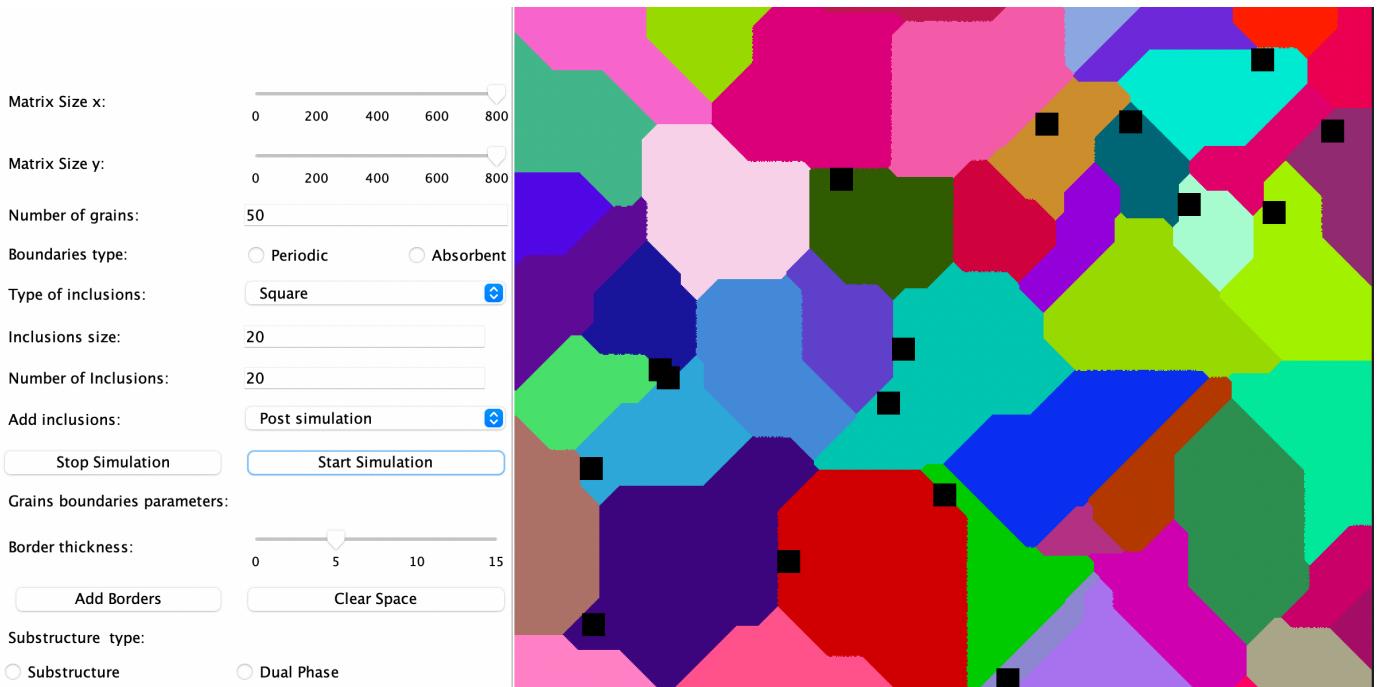
Picture 4. One of the first steps of Grain Growth Simulation with prior, square inclusions for following parameters: Matrix Size X and Y = 800, Number od Seeds 50, number of inclusions 20, inclusions Size 5

### 3.2 Grain Growth simulation with prior Square Inclusions



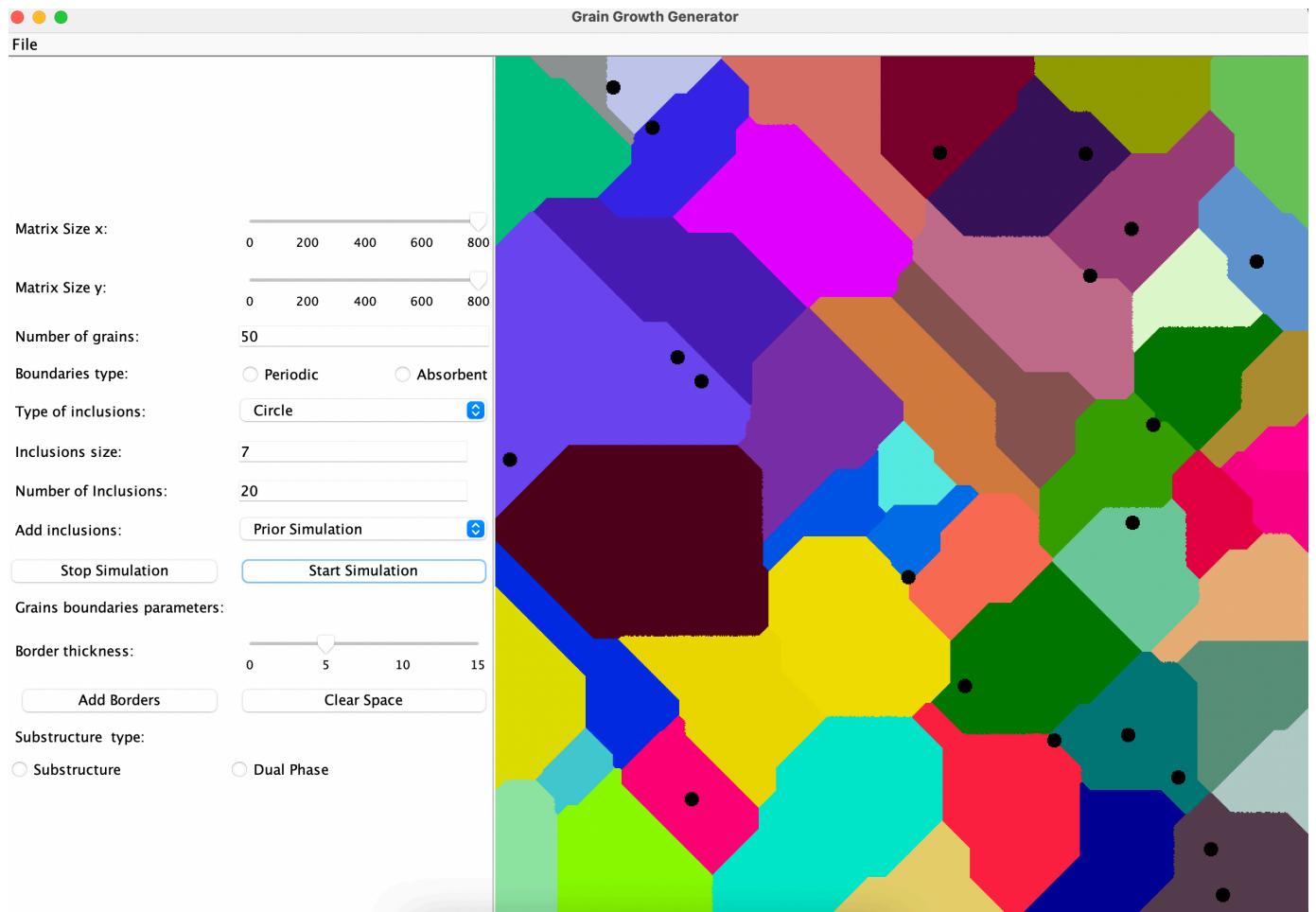
Picture 5. Last step of simulation above. Inclusions are distributed randomly.

### 3.3 Grain Growth simulation with post Square Inclusions



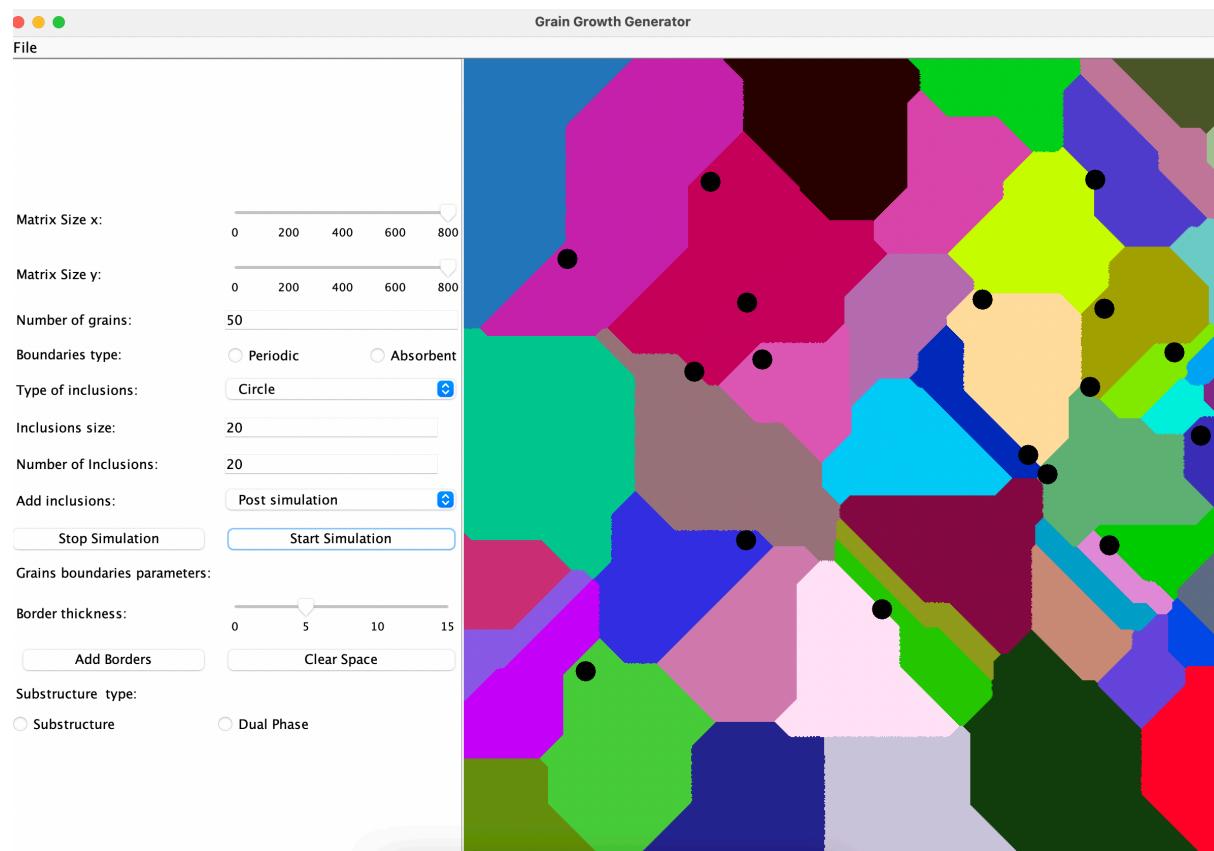
Picture 6. Grain Growth with square post inclusions. Inclusions are always on the grains boundaries.  
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Selected inclusion size 20.

### 3.4 Grain Growth simulation with prior Circular Inclusions



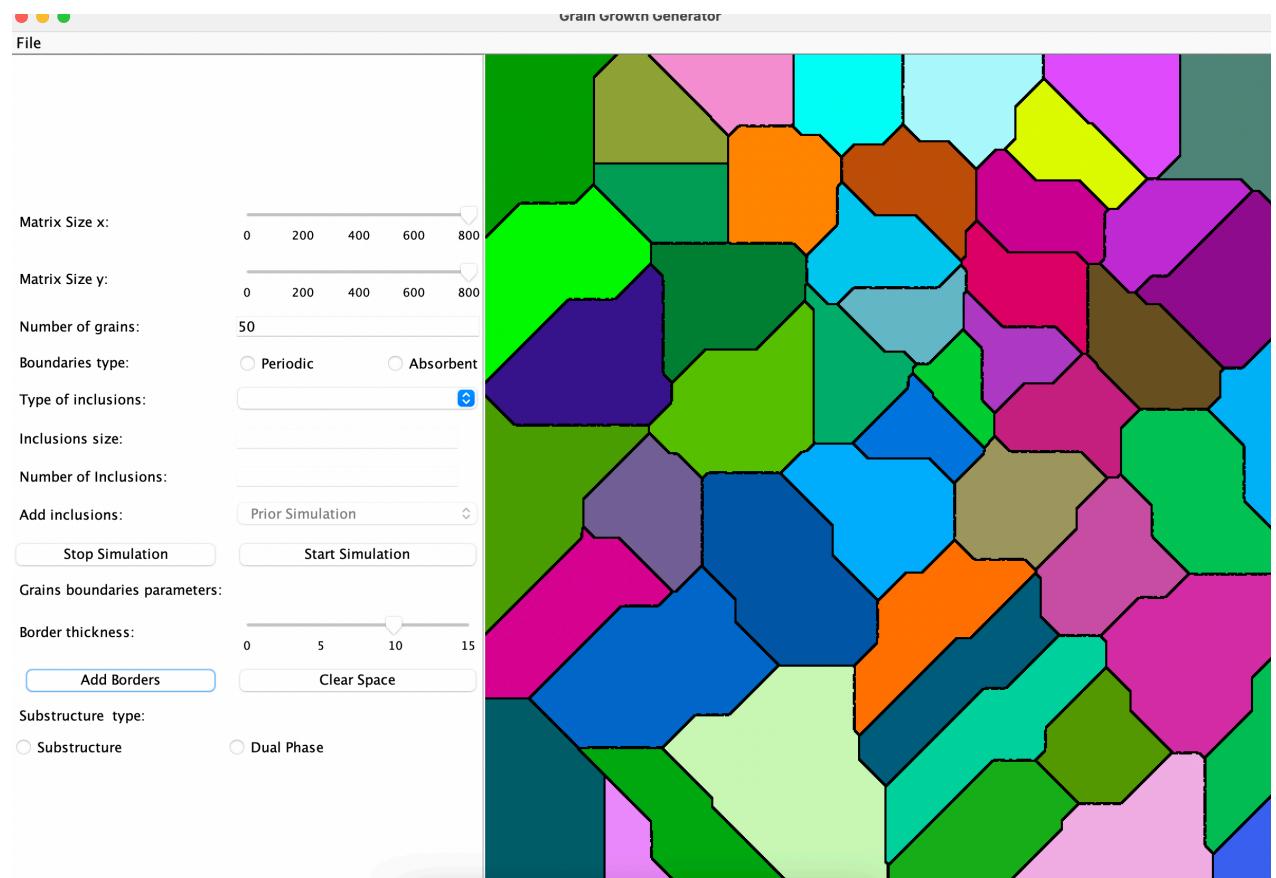
Picture 7. Grain Growth with prior circular inclusions of size 7. Inclusions are distributed randomly.

### 3.5 Grain Growth simulation with post Circular Inclusions



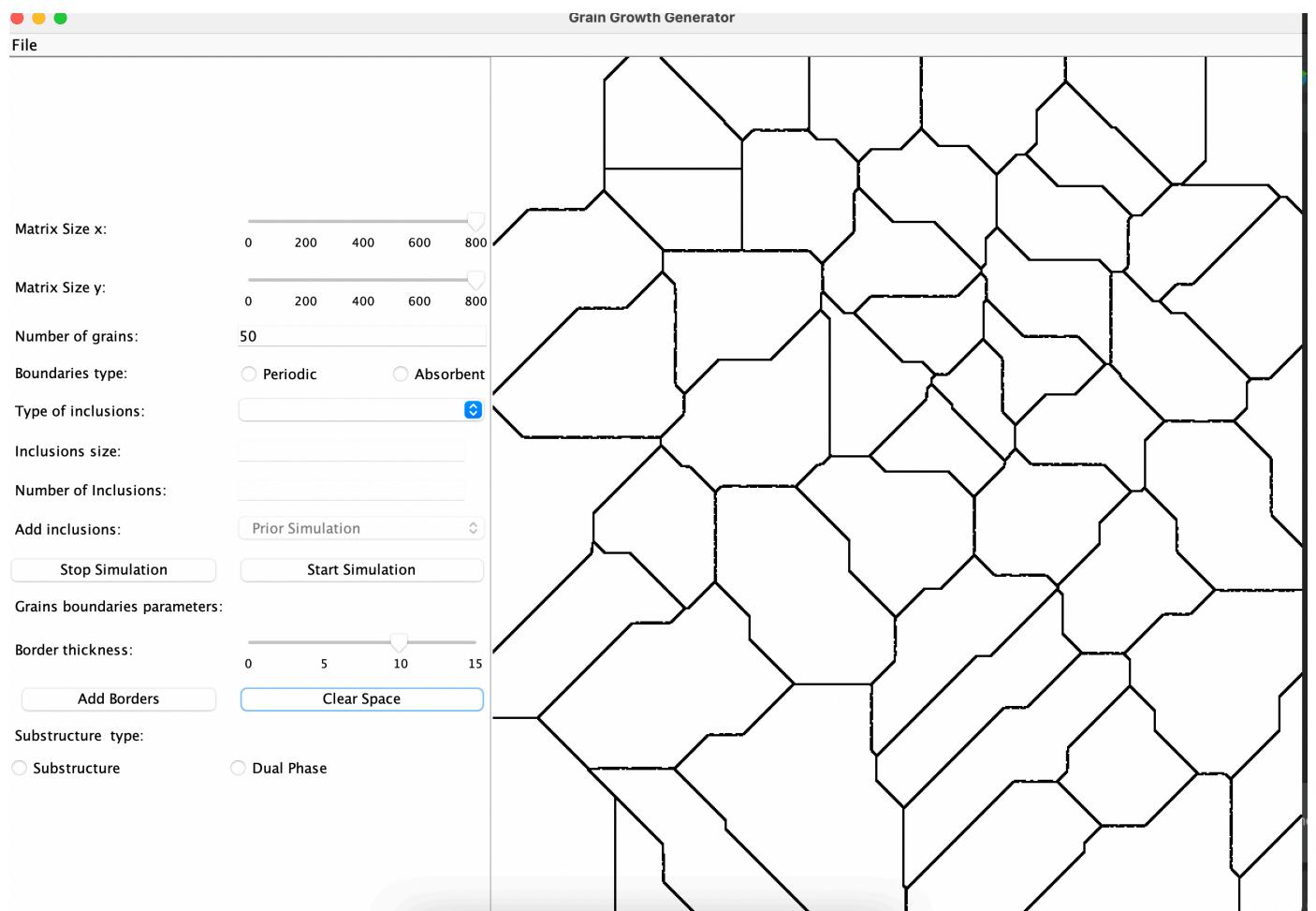
Picture 8. Grain Growth with prior circular inclusions. Inclusions are always on the grains boundaries. Selected inclusion size 20.

### 3.6 Drawing Grains borders



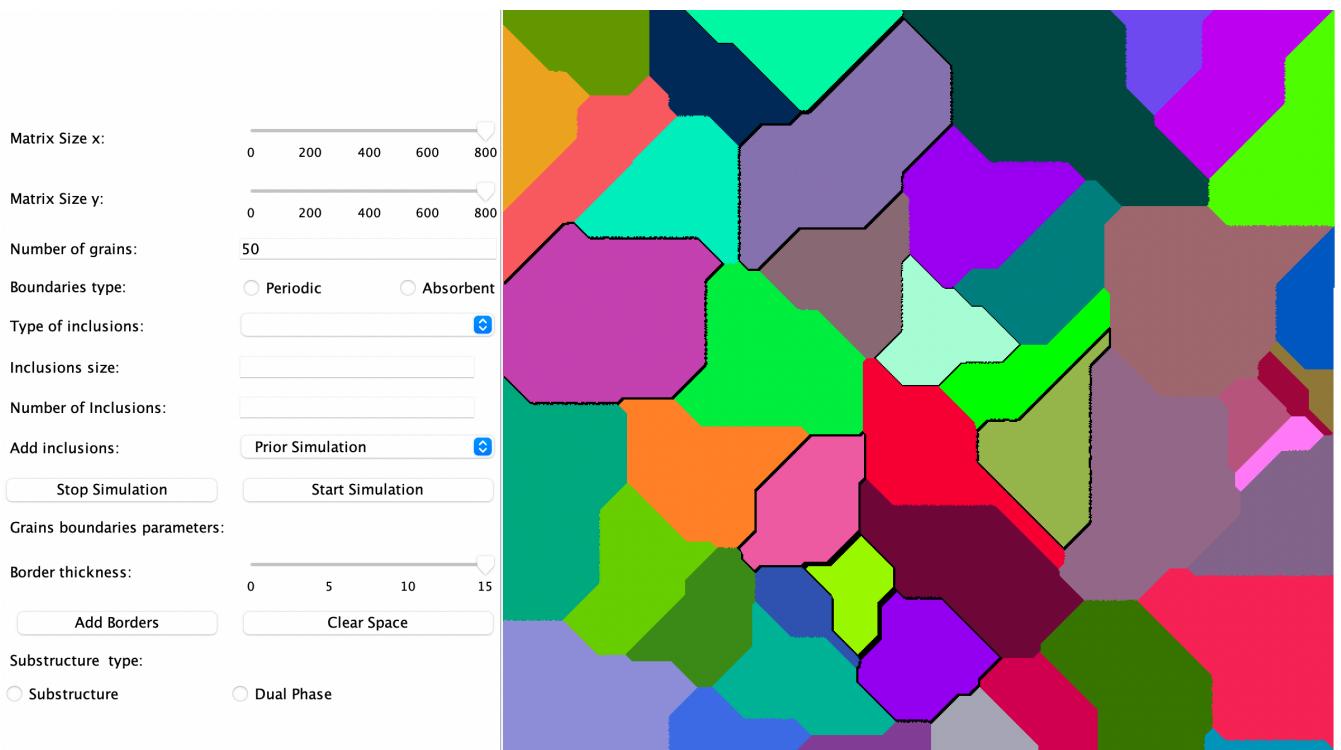
Picture 9. Grains borders drawing with border thickness 10.

### 3.7 Clearing Space

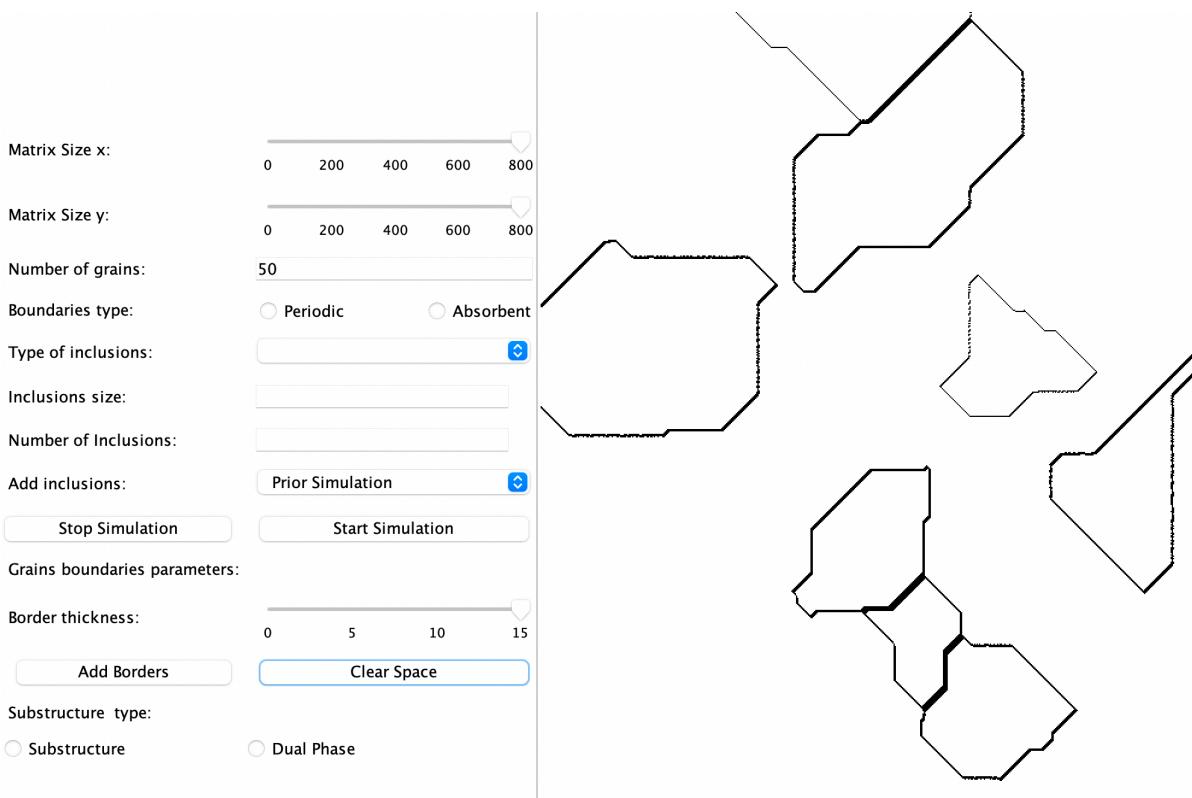


Picture 10. Space cleared, only grains borders left

### 3.8 Painting grains borders and clearing space

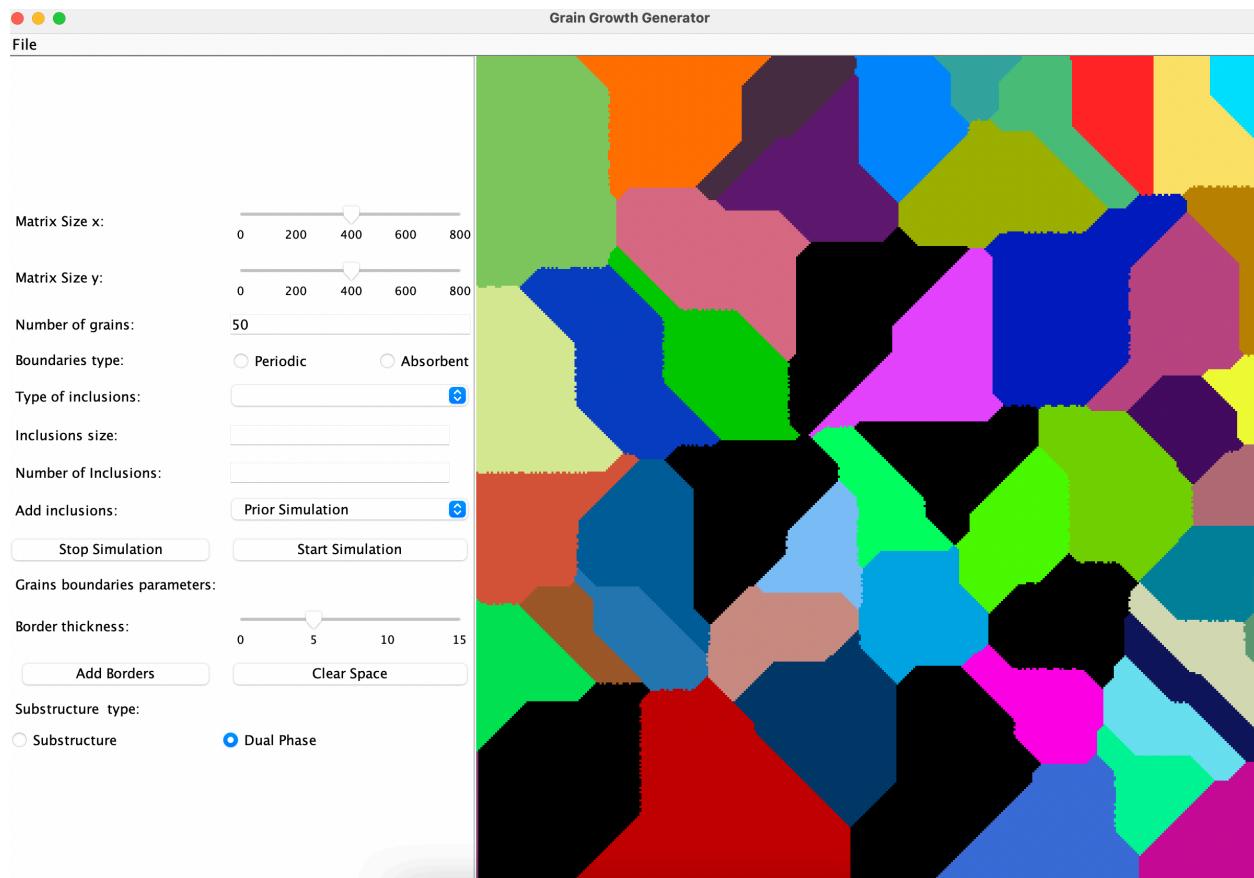


Picture 11. Selected grains boundaries

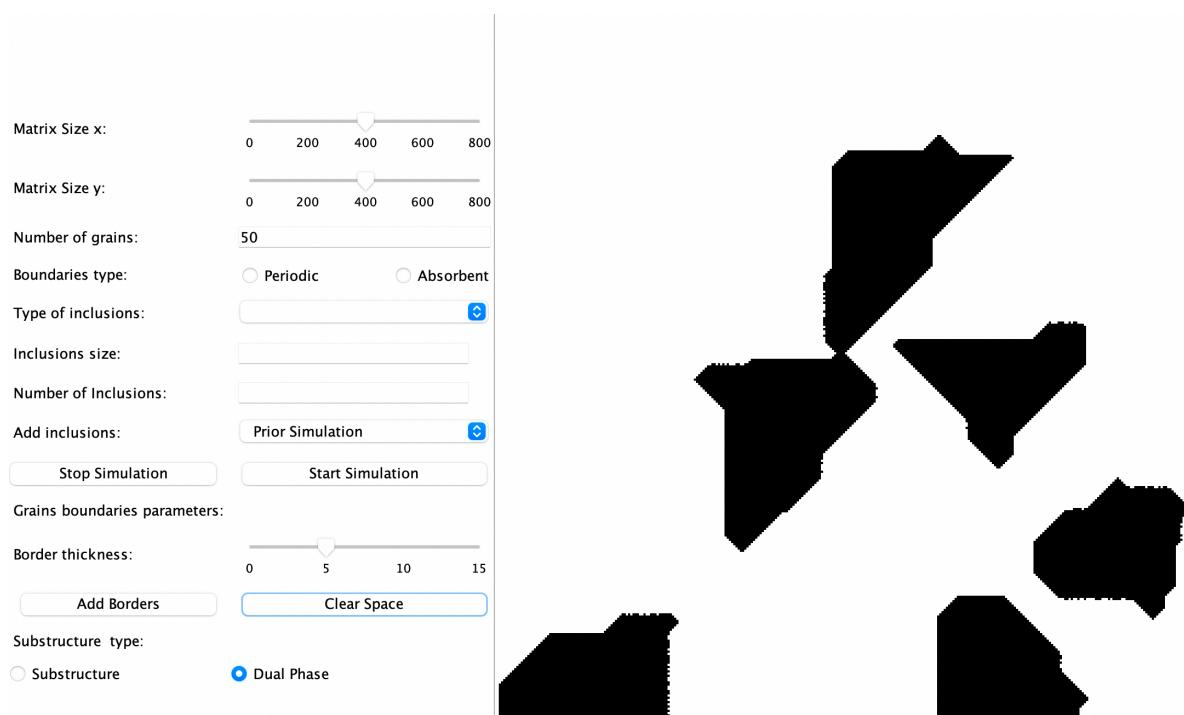


Picture 12. Space cleared for the above

### 3.8 Dual Phase

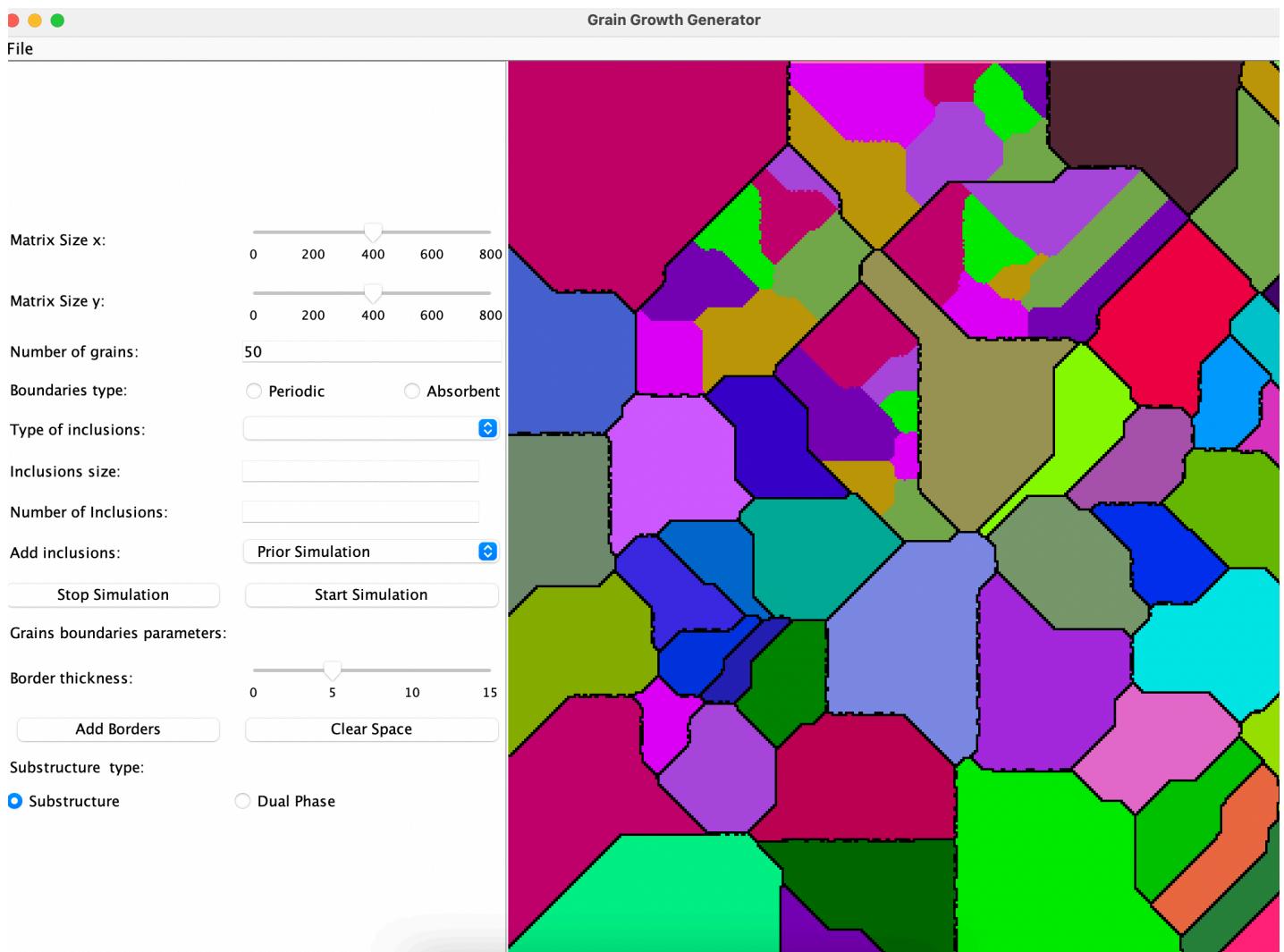


Picture 13. Dual phase, with selected grains



Picture 14. Space cleared for dual phase

### 3.8 Substructure



Picture 15. Substructure in selected grains. Grain borders added in order to better present the substructure.

