1 Method overview

To determine the intergranular versus intragranular attack, a software was written in Python which analyzes EDS images for areas of high Cr concentration and compares the data to SEM images. Images can be represented as matrices of pixels, and each pixel in the EDS data can be represented by three numbers, red, white, and blue. The range of these numbers range from 0 to 255, where the number represents the presence of each color. Because the EDS data is monochrome, the image was grayscaled, which means each pixel was set to the average RGB value.

The SEM was already grayscale, so no pre-processing was done for the SEM images. Both images were then converted to black and white, where light pixels were converted to white, and dark pixels were converted to black. A manually chosen threshold was used to determine the pixel value threshold which differentiates white pixels from black pixels. The software provided a black-and-white image next to the original image to allow the user to select a threshold which adequately represented voids in the SEM image, as well as Cr depletion in EDS images.

Each pixel in both images were then counted row-by-row, and a dataset was built according to eq. (1).

$$c_i = \sum_{j}^{W} p_{i,j} \tag{1}$$

where c_i is the count of white pixels in row i in the pixel matrix, j is the column of the matrix, W is the width of the pixel matrix in the pixel matrix, and $p_{i,j}$ is the value of the pixel in row i and column j (1 for black and 0 for white). The corresponding depth of each row was found by converting pixels to depth using the scale bars on the SEM and EDS images, and the number of black pixels per row as a function of depth was found. For the SEM images, this represented the voids in the material, and for EDS images, this represented the chromium depletion in the material.

To determine the intergranular corrosion as a function of depth, the SEM pixel matrix was compared pixel-by-pixel to the EDS pixel matrix using equation 2.

$$o_{i,j} = \begin{cases} 1 & \text{if } p_{i,j}^{\text{EDS}} = 1 \text{ and } p_{i,j}^{\text{SEM}} = 1 \\ 0 & \text{if otherwise} \end{cases} \tag{2}$$

Where $o_{i,j}$ is the overlaid pixel value of the EDS and SEM images at row i and column j, $p_{i,j}^{\text{EDS}}$ is the value of the EDS pixel matrix and $p_{i,j}^{\text{SEM}}$ is the value of the SEM pixel matrix. This data was then counted using eq. (1) to get the intergranular corrosion. Intragranular corrosion was determined using eq. (3).

$$o_{i,j} = \begin{cases} 1 & \text{if } p_{i,j}^{\text{EDS}} = 1 \text{ and } p_{i,j}^{\text{SEM}} = 0 \\ 0 & \text{if otherwise} \end{cases} \tag{3}$$