Interactive Microstructure Mapping for Exploring Microstructure–Property Relationships

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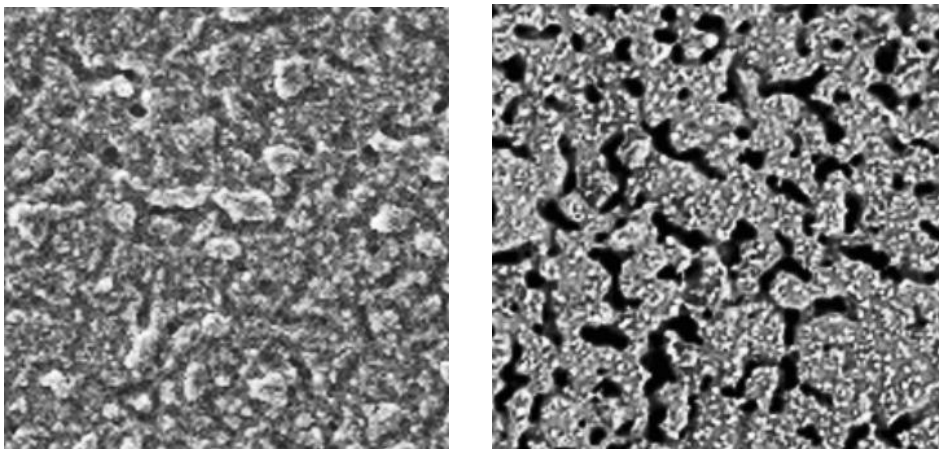
Abstract

Scanning electron images of REBCO thin films fabricated via metal organic deposition using the trifluoroacetate process were acquired and compared to investigate structure–property relationships with regard to the processing parameters of the superconducting thin-films. A software was developed to generate a two-dimensional map in which the microstructure images are placed so that images with similar visual features are located close to each other.

To achieve this, openly available convolutional neural networks (CNN) like ResNet50[1] and pretrained model weights were used to generate high-dimensional vectors encoding visual features of the images in an abstract way. This vector space was transformed into a two-dimensional vector space using the dimensionality reduction algorithm Uniform Manifold Approximation and Projection for Dimension Reduction[2] (UMAP).

The microstructure images were found to arrange in interpretable ways. When the target value J_c (critical current density) was colour-encoded on the interactive map, correlations between regions of low J_c and specific types of microstructural features became visible, providing a proof-of-concept.



(a) (b)

Figure 1: Exemplary SEM Images of Samples a) A dense thin-film with a high J_c b) A more porous thin-film with a lower J_c

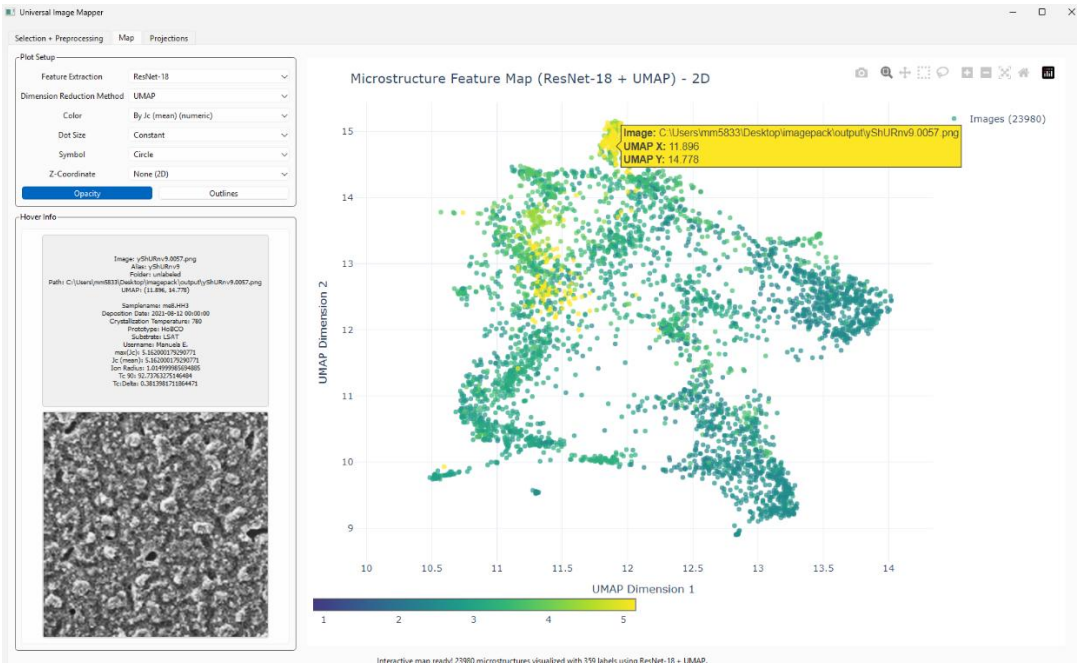


Figure 2: Screenshot of the Application showing the interactive map, colorized by the critical current densities of the samples, each dot represents a different input image

This approach is general and can be applied to arbitrary microscopy images of microstructures. It therefore provides an exploratory tool for detecting links between processing parameters, microstructure and functional properties in a range of applications and materials systems.

References

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2) McInnes, L, Healy, J, *UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction*, arXiv preprint 1802.03426, 2018

Keywords: Microstructure Analysis, Machine Learning, Microstructure-Property-Relationships, Critical Current, Data Analysis, Data Mining