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Application of Novel Techniques to the Three-dimensional Characterization of Microstructural Features in α+β Titanium Alloys

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Advanced three-dimensional data collection techniques such as Robo.Met-3D™ has led to rapid acquisition of robust datasets on optical length scales. Implementation of such datasets may improve the accuracy of neural networks and phase-field models. However, the accurate statistical representation of three-dimensional microstructural features is challenging and thus requires further improvement to analytical methods. This work addresses the serial two-dimensional collection, three-dimensional processing, and analysis of datasets containing microstructural features such as equiaxed-α and colony-α in α+β titanium alloys.

In regards to equiaxed-α, new algorithms, including a novel 3-D adaptive threshold, have been developed for the three-dimensional identification and isolation of equiaxed-α particles from the α+β-processed microstructure. Furthermore, innovative, automated separation subroutines have been constructed and applied to the identified equiaxed-α particles. Such subroutines have resulted in three-dimensional separation of particle clusters into several discrete features that were falsely joined by segmentation artifacts from less robust algorithms *(see FIG. 1)*. Made possible by accurate particle identification and separation, as well as the development of a MATLAB-based toolkit, 3-D quantification was performed on a global and feature-by-feature basis. The extracted 3-D measurements were compared to their 2-D counterparts, leading to an exploration of the representative volume element (RVE) and its dependence on the measurement of interest.

With regard to colony-α, a large 3-D dataset of Ti-5111 has been collected using Robo.Met-3D™ and subsequently aligned with high fidelity using the afore-mentioned MATLAB-based toolkit. Through collaboration with Dr. Surya Kalidindi and his group at Drexel University, the dataset was automatically segmented into the various colony orientations using two-point correlation. Several colony orientations were then three-dimensionally reconstructed, allowing for the unique 3-D visualization of their interpenetrating morphology *(see FIG. 2)*. Crystallographic information has been incorporated using electron backscatter diffraction (EBSD) and was subsequently integrated into 3-D quantification of the reconstructed colonies.

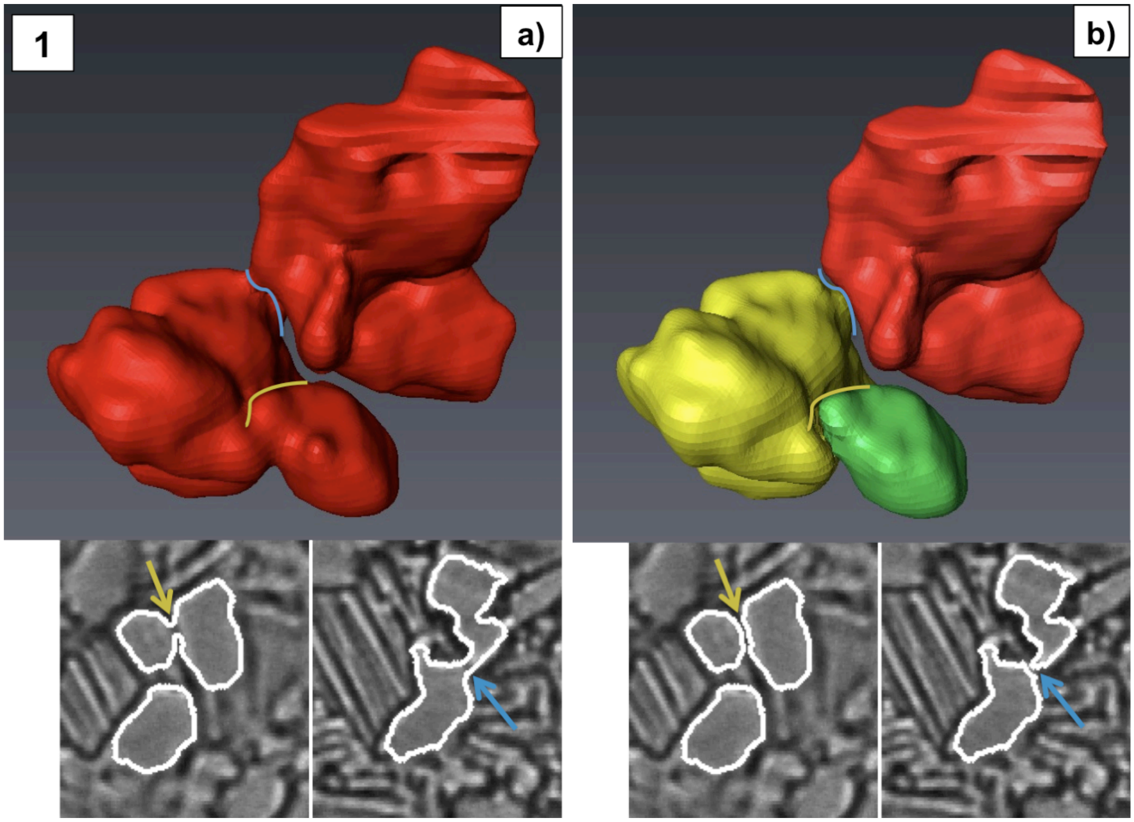

FIG. 1. An example of automated 3-D equiaxed-α particle separation showing an a) un-separated cluster of three particles and b) the separated particles from a novel 3-D separation algorithm.

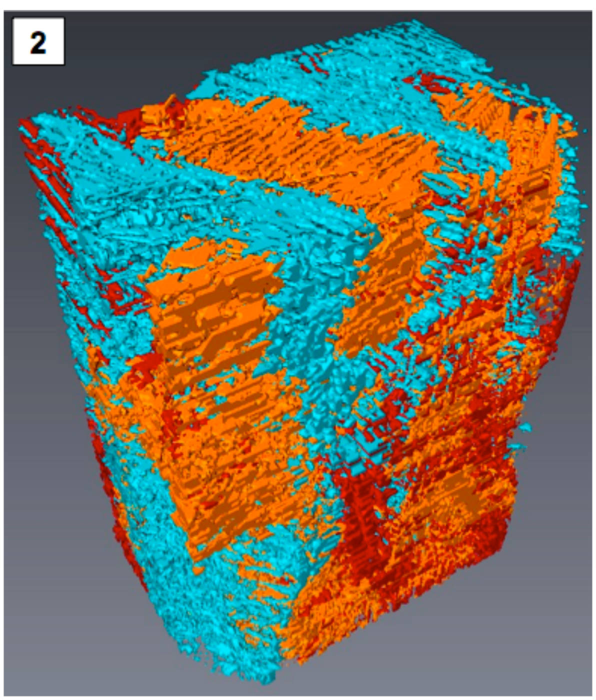

FIG. 2. A 3-D reconstruction of three colony orientations revealing their interpenetrating morphology. Each color indicates a discrete orientation.

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