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Advanced 3-D Reconstruction Algorithms for Electron Tomography

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Electron tomography in the physical sciences has become a powerful tool for nanomaterial analysis. Recently, electron tomography is finding applications in more beam sensitive materials such as catalysts. For beam sensitive materials, the goal is to acquire the smallest number of images as possible but still maintain an accurate and high resolution 3-D reconstruction. Standard methods of 3D reconstruction, such as weighted back projection (WBP) and simultaneous iterative reconstruction technique (SIRT), are not equipped to handle this lack of information, and create significant blurring. This gives rise to a search for new methods of reconstruction. Two of the recent successful algorithms are the discrete algebraic reconstruction technique (DART) and total variation (TV) minimization within compressed sensing (CS).

The DART algorithm uses ART and pairs it with the prior knowledge that there are only a small number (two or three) of different materials in the sample, each corresponding to a different gray value in the reconstruction. An initial reconstruction is computed and rounded to the chosen fixed gray values based on some threshold, and iteratively refined using ART. The method of TV minimization stems from the mathematical theory of compressed sensing and only recently became available due to new algorithms for solving the TV minimization problem. The method considers the characterization of real images and encourages the reconstruction to take larger jumps in gray values to create clear boundaries, hence creating a similar effect to that of DART.

The advantage of DART is that an accurate selection of the gray values and the rounding procedure for the reconstruction gives extremely valuable information otherwise not available in any other reconstruction technique. The TV minimization procedure has fewer parameter selections, giving a stable method for reconstruction. Moreover, the introduction of the TV norm has the potential for creating boundaries alternate to what a DART reconstruction would find. Both methods are extremely valuable. In this presentation we discuss the pros and cons of each method, and show examples to illustrate when to use one method over the other. One comparison is shown in Figures 1-2 to demonstrate the differences for a layered zeolite material.

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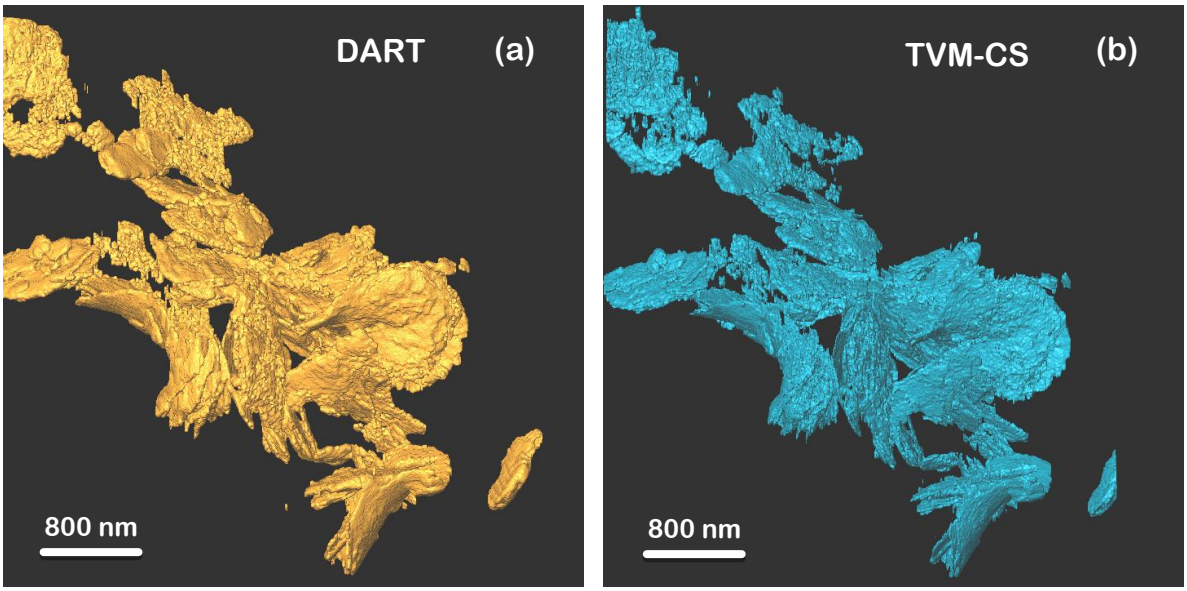

Figure 1. (a) shows the overall 3-D reconstruction using DART, and (b) shows the overall reconstruction using TV minimization within CS.

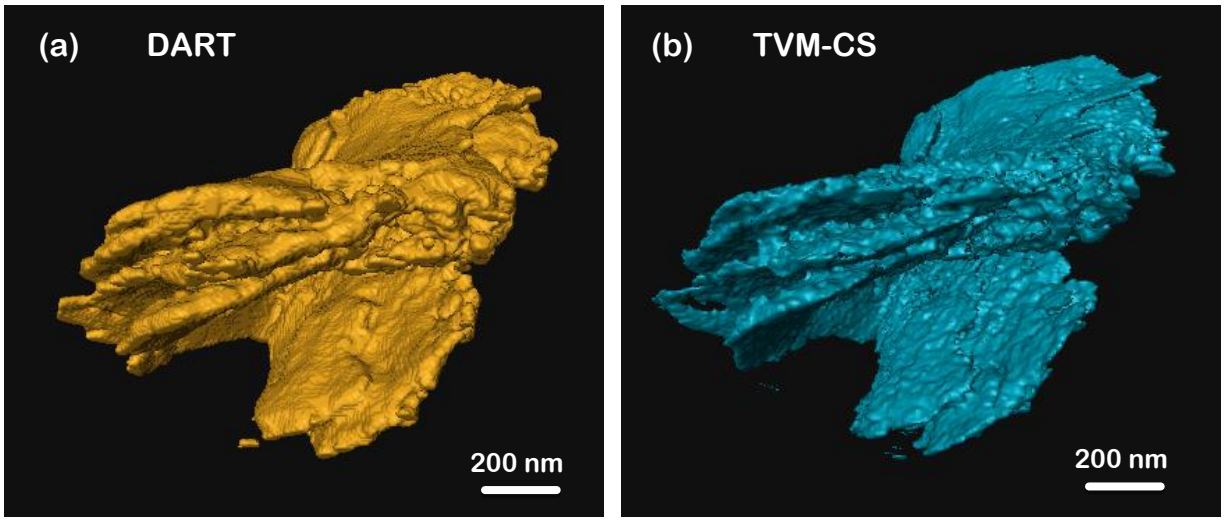

Figure 2. (a) shows one cluster reconstructed using DART, and (b) shows one cluster reconstructed using TV minimization within CS.

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