doi:10.1017/S1431927622009515
Microsc. Microanal. 28 (Suppl 1), 2022
© Microscopy Society of America 2022

Imaging of Defect Rich Heterogeneous Interfaces using Compressive Sensing STEM

Daniel Nicholls[1*], Jack Wells[2], Mounib Bahri[1], Nigel D. Browning[1,3,4,5]

[1.] Department of Mechanical, Materials and Aerospace Engineering, University of Liverpool, Liverpool, L69 3GH, United Kingdom

[2.] Distributed Algorithms Centre for Doctoral Training, University of Liverpool, Liverpool, L69 3GH, United Kingdom

[3.] Physical and Computational Science Directorate, Pacific Northwest National Laboratory, Richland, WA 99352, USA

[4.] Sivananthan Laboratories, 590 Territorial Drive, Bolingbrook, IL 60440. USA

[5.] The Faraday Institution, Quad One, Harwell Science and Innovation Campus, Didcot OX11 0RA, United Kingdom

[*] Corresponding author: d.nicholls@liverpool.ac.uk

Compressive sensing (CS) scanning transmission electron microscopy (STEM) has been used to both increase the acquisition rate [1] and lower the electron dose [2] required to form high resolution images of both crystalline and non-crystalline structures [3] by the use of probe subsampling and an appropriate dictionary learning algorithm, such Beta Process Factor Analysis (BPFA) [4]. Presented here is an application of compressive sensing to the imaging of a cadmium telluride (CdTe) thin film solar cell material on a silicon (Si) substrate, with a focus on the many defects present in the sample and the interface between the CdTe and Si. The interface of these materials and the number and location of defects [5] affects the efficiency of the solar material and therefore is of high importance to manufacturers. As such, during the application of CS to these materials it is vital that the interface and defects are retained during the inpainting process.

The CdTe lamella was prepared by FIB preparation using a FEI Helios Nanolab 600i dualbeam FIB/SEM and the STEM imaging was carried out using an aberration corrected JEOL 2100F. The images were subsampled artificially and inpainted using the Nuxutura Image Inpainting software, which utilises a Beta Process Factor Analysis with Expectation Maximisation (BPFA-EM) algorithm implementation.

Figure 1 shows an annular bright field STEM image of the interface between CdTe and Si with many defects present, an artificially subsampled image of the CdTe-Si interface, and the BPFA-EM reconstruction of that subsampled image. The reconstruction shows that both the interface and defects are retained through the subsampling and reconstruction process with sufficient quality to be analysed. Figure 2 shows the same schematic as Figure 1 except using a linehop sampling pattern rather than a random sampling pattern. Again, the atomic information along with the interface and defects are retained through the subsampling and inpainting process.

References:

1. Stevens, A., et al., *Applying compressive sensing to TEM video: a substantial frame rate increase on any camera.* Advanced Structural and Chemical Imaging, 2015. **1**(1).
2. Stevens, A., et al., *The potential for Bayesian compressive sensing to significantly reduce electron dose in high-resolution STEM images.* Microscopy (Oxf), 2014. **63**(1): p. 41-51.
3. Nicholls, D., et al., *Sub-Sampled Imaging for STEM: Maximising Image Speed, Resolution and Precision Through Reconstruction Parameter Refinement.* Submitted, 2021.

CrossMark
https://doi.org/10.1017/S1431927622009515 Published online by Cambridge University Press

4. Sertoglu, S. and J. Paisley, *Scalabe Bayesian nonparametric dictionary learning.* 23rd European Signal Processing Conference (EUSIPCO), 2015: p. 2771-2775.
5. Berding, M., *Native defects in CdTe.* Physical Review B, 1999. **60**(12): p. 8943.

https://doi.org/10.1017/S1431927622009515 Published online by Cambridge University Press