aquaDenoising: AI-Enhancement of *in situ* Liquid Phase STEM Video for Automated Quantification of Nanoparticles Growth

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Understanding of the formation mechanism of metallic nanoparticles (NPs) has over recent years greatly benefitted from in situ liquid TEM that enables imaging the nucleation and growth of individual NPs in liquid media. However, these experiments pose challenges regarding both imaging and data analysis. Substantial scattering from the liquid around the nano-objects and the electron transparent SiN membranes significantly diminishes the signal quality [1]. One solution would be to increase the electron dose rate, but this can lead to undesirable effects due to radiolysis.

To address this issue, we propose aquaDenoising, an innovative approach that combines artificial intelligence and scanning transmission electron microscopy kinematic simulations [2]. Our approach enables the differentiation and extraction of valuable signals from unwanted background fluctuations and noises in liquid dark-field STEM sequences. Besides considering the size and shape dispersions of nanoparticles, our kinematic simulations account for a significant obstacle in studying NP growth by liquid cell TEM: the formation of NPs on the opposite membrane of the cell that contribute to the random background fluctuations because they are imaged way out-focus. Considering these challenges, our method effectively denoises low and high magnification videos, elevating the signal-to-noise ratio (SNR) from 1.6 to 25 [Fig. 1], above the threshold value of 5 set by the Rose criterion. Consequently, aquaDenoising facilitates the study of NP growth mechanisms with improved statistics and fewer acquisition constraints. We will show application of this methodology to investigate surface site attractiveness on both gold nanocubes and nanorods within the context of NP synthesis.

References

[1] Niels de Jonge, Ultramicroscopy, 187 (2018) 113-125.
[2] Dongsheng He, Ziyou Li and Jun Yuan, Micron, 74 (2015) 47-53.

Figures

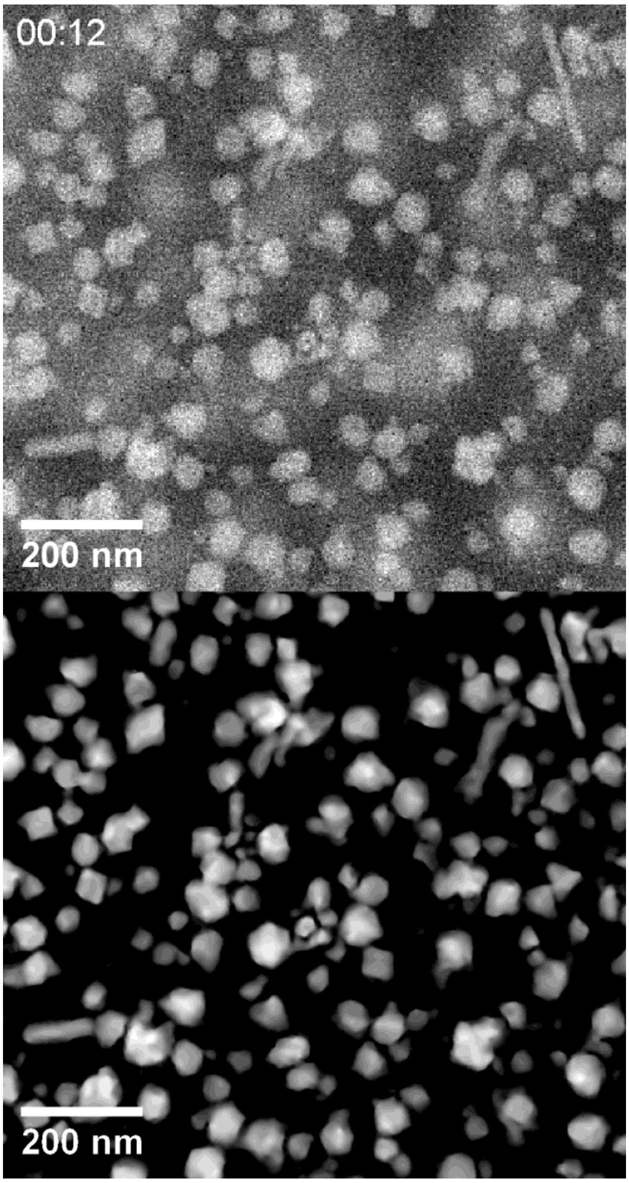

Figure 1. (a) Frame from the experimental video of the *in situ* liquid growth of nanoparticles. (b) Same frame denoised using the aquaDenoising approach.