Algorithmic Detection of Oxide Nanosheets

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Oxide nanosheets with a wide bandgap have high dielectric properties, and they are single crystals delaminated by chemical exfoliation of bulk layered materials. These crystallites have an approximate thickness of 1 nm and a lateral size of up to 10 μm. The oxide nanosheets have demonstrated potential applications in a wide array of high-k dielectric [1], photocatalytic [2], photoluminescence [3], and p-n junction diode [4] applications. $Ca_2Nb_3O_{10}$ (CNO) nanosheets, a typical member of oxide nanosheets, have excellent dielectric properties due to their high dielectric performance related to $C = (\varepsilon_r A) / d$. Thus, the thinner the dielectric layer in the capacitor composed of metal-dielectric-metal layers, the larger the capacity that can be stored. Therefore, it is necessary to use dielectric oxide nanosheets, having a thickness in the nanometer range.

A common method to detect oxide nanosheets is to use Atomic Force Microscopy (AFM) to scan the material, and manually locate them in the scanned image. Our preliminary study aims to automate this process with an algorithmic approach. Current studies focus on determining the thickness of other types of nanosheets [5, 6]. Our approach relies on the physical thickness of the CNO nanosheets while watching out for artefacts on an AFM image. Figure 1 displays the plot of a row from an AFM image (Figure 2, left). The image has artefacts such as stripe noises and intensity inhomogeneity (increased intensity along one diagonal in this case). For each row, we first detrend the signal to eliminate such gradual intensity changes, remove outliers, use difference-based derivative estimation, so that the edges of potential nanosheets can be detected. As a result, we get the red markers in Figure 1, which are used as change points in the signal. We mark the pixels that are empirically close to the mean and have a low mean squared error. The resulting pixels are the nanosheets, as shown in Figure 2.

References

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Figures

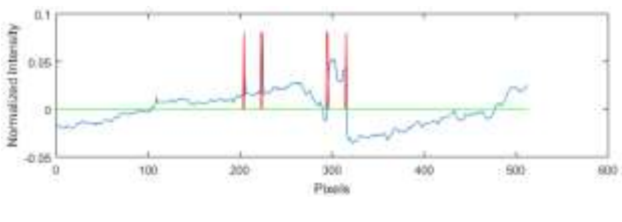

Figure 1: A normalised signal for a row in an AFM image, the detected change points are in red.

Figure 2: The oxide nanosheets on the left image are detected, as shown on the right.