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# Roughness scaling extraction method for fractal dimension evaluation based on a single morphological image

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## Abstract

Fractal dimension ( $D$ ) is an effective parameter to represent the irregularity and fragmental property of a self-affine surface, which is common in physical vapor deposited thin films.  $D$  could be evaluated through the scaling performance of surface roughness by using atomic force microscopy (AFM) measurements, but lots of AFM images with different scales ( $L$ ) are needed. In this study, a roughness scaling extraction (RSE) method was proposed to evaluate  $D$  values of a single AFM image, in which the roughness at smaller  $L$  was estimated by image segmentation with flatten modification. Firstly, a series of artificial fractal surfaces with ideal dimension ( $D_i$ ) values ranging from 2.1 to 2.9 were generated through Weierstrass-Mandelbrot (W-M) function, in order to compare RSE method with traditional methods such as box counting method and power spectral density method. The calculated dimension ( $D_c$ ) by RSE method was much closer to  $D_i$  than the other methods, with a mean relative error of only 0.64%. Secondly, RSE method was utilized to deal with real surfaces, which were AFM images of amorphous alumina thin films with  $L$  of 1-70  $\mu\text{m}$ .  $D_c$  obtained by RSE method based on a single AFM image was also close to the result in our previous study by multi-image analysis at  $L$  above 10  $\mu\text{m}$ , while the larger  $D_c$  at smaller  $L$  was consisted with the actual surface feature. The validity of RSE method and

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