Method to estimate the process parameters for plasma-enhanced atomic layer deposition using deep learning techniques

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Abstract

Finding the plasma process parameters from experimental data such as scanning electron microscope (SEM) and transmission electron microscope (TEM) images is essential and challenging for the plasma process engineer. Recently, the process conditions have been speculated through the computational analytic method using a plasma process simulator. It can provide a better understanding link between process operation conditions and experimental results. However, it is time- and work-power-consuming because of some unknown parameters. This work demonstrates that the deep learning technique can find the plasma-enhanced atomic layer deposition (PEALD) process parameters, such as precursor flux and sticking coefficient, also process time from TEM images. To train the convolution neural network (CNN), we generated the virtual 3D PEALD profiles using technology computer-aided design (TCAD) software at least 3,000 with PEALD surface reaction modeling equation. The developed CNN, which we called CNN-ALD, was applied to estimate the plasma process conditions. The results show good consistency with the reported properties and experimental data, so it was possible to suggest connecting the theoretical and empirical approaches from the CNN model with various process conditions and surface reaction modeling studies.