

# Layer-by-layer etching of copper thin films under acetylacetone/O<sub>2</sub> gas mixture

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Previously, acetylacetone (acac) was employed at the gas cluster ion beam etching for copper films. They reported that the etch depth of copper using acac and O<sub>2</sub> gas mixture was deeper than that of copper using O<sub>2</sub> gas only, introducing the possibility of etching for copper films. However, they presented no etch profiles on copper films [1].

In this study, layer-by-layer etching of copper thin films was performed using acac/O<sub>2</sub> gas mixture and Ar plasma. Layer-by-layer etching involves two-step procedure, which contains the surface modification by the exposure of copper films to acac/O<sub>2</sub> gas and the elimination of the modified layers by the sputtering of Ar ions. The surface modification step was optimized by varying the flow-rate ratio of acac/O<sub>2</sub> gases and exposure time, which led to the oxidation of copper films and the formation of copper compounds. In addition, the elimination step also was developed by changing the dc-bias voltage to the substrate and sputtering time. The surface modification and elimination of the modified layers were verified by X-ray photoelectron spectroscopy and energy dispersive X-ray spectroscopy. The etch per cycle was obtained in the range of 0.7-3.0 nm/cycle, relying on the Ar sputtering at the fixed exposure condition. Layer-by-layer etching of copper films masked with SiO<sub>2</sub> presented good etch profiles without redepositions. Layer-by-layer etching of copper films using acac/O<sub>2</sub> gas mixtures can be one choice to demonstrate the fine pattern on copper films.

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**References** [1] N. Toyoda, & K. Uematsu, Jpn. J. Appl. Phys., 58(SE), S5EA01, (2019).