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Supercritical Fluid Chemical Deposition of Cu in Ru-lined Deep Nanotrenches using a New Cu(I) Amidinate Precursor

Univ. of Yamanashi [1], Gas-Phase Growth Ltd. [2], °Md Rasadujjaman[1], Mitsuhiro Watanabe[1], Hiroshi Sudo[2], Hideaki Machida[2] and Eiichi Kondoh[1]

E-mail: rasadphy@duet.ac.bd

Supercritical fluid chemical deposition (SFCD) technique is highly effective for filling high-aspect ratio features [1]. This method has already been utilized using several organic Cu^{II}-precursor like $Cu(hfac)_2$, $Cu(dibm)_2$ for Cu-deposition. Both of these precursors have low reactivity, which requires high decomposition temperature. Decomposition of the precursors leads to the incorporation of carbon and oxygen impurities, which degraded the quality of the films. The fluorine in the $Cu(hfac)_2$ caused fluorine contamination of the films which reduced adhesion of Cu to substrate. In addition, they have low reactivity with H_2 due to the Cu-O bonds, which require high decomposition temperature, leading to rough Cu films with carbon and oxygen contamination.

We report the SFCD deposition of pure Cu-films using a new Cu precursor diisopropylpropion amidinate copper (I) dimer, $[Cu(DIPPA)]_2$. The chemical structure of this compound is shown in Fig. 1. Deposition was carried out at 120-240 ºC using Ru-lined test structure. The new Cu-precursor were found to be reactive at lower temperatures (e.g. 140 ºC) than $Cu(hfac)_2$ and $Cu(dibm)_2$.

Figure 2 shows cross sectional SEM images of nano trench fill patterns at 140 ºC and 240 ºC on a Ru surface. At lower temperature (140 ºC) [Fig. 2(a)] it is shown that 140 nm and 180 nm trenches were completely filled with Cu. This temperature for Cu fill was much lower than those optimized for Cu^{II} precursors; practically no Cu deposition occurred from Cu^{II} precursors at 140 ºC. However, when the temperature was further increased to 240 ºC [Fig. (b)] copper nuclei diffusion become faster leading to the formation of grain worsening and agglomeration.

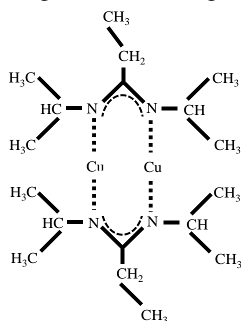

Fig. 1. Chemical structure of the Cu(I) amidinate precursor; $[Cu(DIPPA)]_2$.

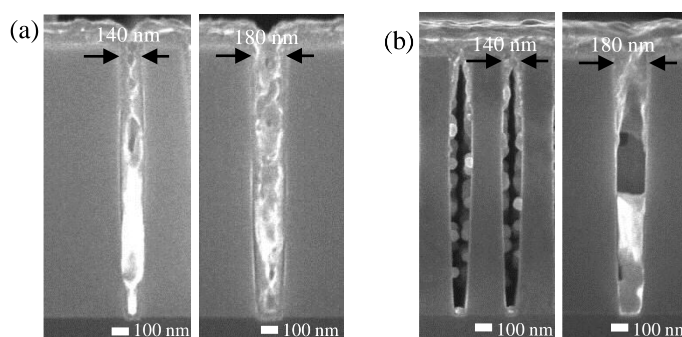

Fig. 2. Cross-sectional SEM images of Cu films deposited using new Cu(I) amidinate precursor at (a) 140 ºC and (b) 240 ºC

In conclusion, supercritical carbon dioxide ($scCO_2$) deposition techniques comforts the use of the new Cu-precursor, $[Cu(DIPPA)]_2$ at lower temperature (140 ºC) for interconnect applications.

Reference

[1] M. Watanabe, et al., Jpn. J. Appl. Phys. (2012) 51: 05EA01.

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