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X-ray scattering study of copper-filling profile in submicron trenches

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Superconformal copper electrodeposition in the damascene process for ULSI results from more rapid growth at the bottom of the trenches than at the sidewalls.¹ To observe this gap-filling dynamics, we performed the reflectivity measurement of damascene-fabricated Cu lines in submicron trenches. To characterize the various gap-filling profiles by x-ray diffraction, we used laterally structured oxide layer as trench to the scale of $0.18\mu\text{m}$. X-ray diffraction measurements in the region of small incidence and exit angles were investigated. In this regime, we can observe the high order truncation rods peculiar to grating surface structure.^{2,3,4,5} A partially filled copper and a super-filled copper show different truncation rods shape in the reciprocal space. In case of partially filled damascene copper, rough side walls as well as irregular void shape diminish the intensity of the non-zero truncation rods so that the high order truncation rods are less observable compared with those of super-filled copper. Thus, we can characterize gap-filling profiles by fitting the amplitude of truncation rods in the reciprocal space. The results of our data-fitting procedure are also discussed in relation to the filling ratio between bottom-up with sidewall-shift.

[References]

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