Electrochemical Deposition of Nanotwinned Cu in Damascene Features

imec: A. Radisic[a,*], [a], Z. El-Mekki[a], E. Shafahian[a], P. K. M. K. Gowda[a], J. Derakhshandeh[a], S. Dewilde[a], K. Devriendt[a], M. Van de Peer[a], J. De Messemaeker[a], F. C. Mascarenhas[a], and H. Struyf[a]
BASF: C.-H. Hsia[b], S.H. Park[c], S. Watanabe[d], and M. Arnold[d]
[a] *imec, 3001 Leuven, Belgium*
[b] *BASF Taiwan Ltd, 32853 Taoyuan, Taiwan*
[c] *BASF Company Ltd., (16419) Suwon-si, Gyeonggi-do, Korea*
[d] *BASF SE, 67056 Ludwigshafen am Rhein, Germany*

We have explored electrochemical deposition of highly (111) oriented nanotwinned (nt-)Cu [References 1-4] in damascene features. Electrochemical deposition of nt-Cu was tested initially on a coupon-scale and after process optimization transferred to (∅300mm) wafer-level commercial plating tool. The goal was to deposit nt-Cu without having to modify hardware on the plating tool, resorting to complex deposition waveforms or other experimental parameters/setups atypical for Cu plating of ∅300mm wafers.

Successful deposition of nt-Cu on ∅300mm blanket wafers and tuning of the Chemical mechanical polishing (CMP) processing was followed by first tests on patterned damascene structures. Quality of the Cu fill was checked against different feature sizes and their aspect ratios (AR). Cylindrical (disc) damascene structures had diameter ranging from 1 to 100 micron and depth from 500 nanometers to 2 microns. Figure 1 shows cross section FIB image zoomed-in on the central part (not showing field and sidewalls) of the 2-micron deep feature having diameter of 20 microns. Please note that no characteristic pyramids on top of highly (111) oriented nt-Cu are observed since Cu overburden has been CMP-ed prior to FIB analysis.

We report on the feature size and AR dependence of the Cu fill, degree of (111) orientation of plated Cu, thickness of the transition zone and other properties relevant for electrochemically deposited nt-Cu. Based on the collected data, we attempt to extrapolate the findings to feature sizes and AR that could be relevant for future applications.

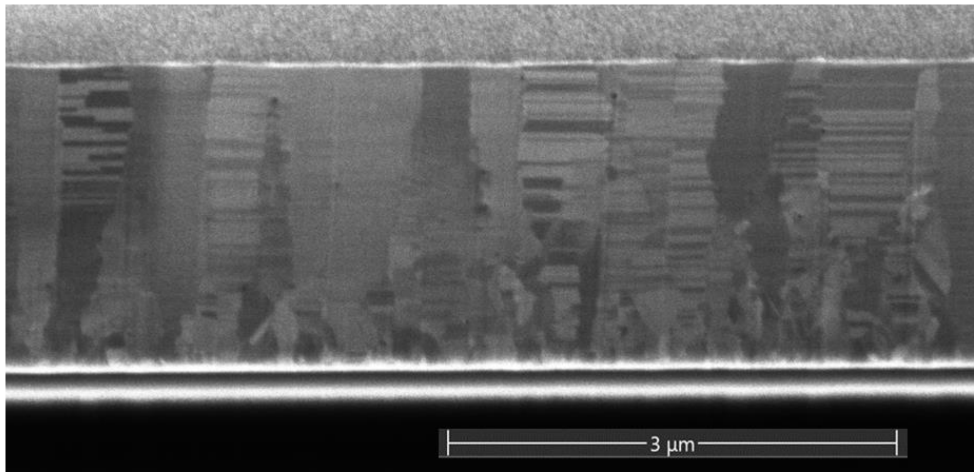

Figure 1. Cross-section FIB image of the central part of the nt-Cu filled damascene feature. CMP has been performed prior to FIB analysis and Cu overburden removed.

References

1. L. Lu *et al*, *Science*, **304**, 422 (2004); DOI: 10.1126/science.1092905
2. C.-M. Liu, H.-W. Lin, Y.-S. Huang, Y.-C. Chu, C. Chen, D.-R. Lyu, K.-N. Chen and K.-N. Tu, *Sci. Rep.*, **5**, 9734 (2015).
3. C.-H. Tseng and C. Chen, *Cryst. Growth Des.* **19**, 81 (2019).
4. L. Mirkarimi, C. Uzoh, D. Suwito, B. Lee, G. Fountain, T. Workman, J. Theil, and G. Gao, B. Buckalew, J. Oberst, T. Ponnuswamy, 2022 IEEE 72nd Electronic Components and Technology Conference (ECTC), DOI: 10.1109/ECTC51906.2022.00036.

* *corresponding author e-mail: Alex.Radisic@imec.be*