CONTROLING SHAPE FORMATION OF COPPER MICROSTRUCTURES FABRICATED BY LOCALIZED ELECTROCHIMICAL DEPOSITION

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Shape formation of copper microstructures, fabricated by localized electrochemical deposition, is controlled to a confined geometry by using tracking tip-withdrawal technique and tapered-end electrode geometry.

INTRODUCTION & MOTIVATION

The ability to control the shape of electrochemically deposited microstructures is of great importance to fabricated electrical devices, where geometrical details largely influence their electrical characteristics. Of interest to this project is the control of high aspect ratio copper columns fabricated by local electrochemical deposition. Such structures can be used as radiating elements, monopole antennas for example, where factors like deposition dimensions and porosity would highly affect the electrical impedance of the element and its radiating efficiency. The profile of electrochemically deposited copper columns would commonly include a base with dimensions much larger than that of the column itself. A technique for the control of deposition is thus required to obtain deposition geometry with confined dimensions from its start till the end.

TIP-WITHDRAWAL & TIP GEOMETRY EFFECTS

The effect of two factors influencing deposited geometry is investigated by evaluating the deposition profile based on calculating the electric field, between deposition electrode and the substrate, using a boundary element approach (1). The first investigated factor is the tip-withdrawal away from deposition surface as it is moved along the locus of desired geometry. Two schemes are considered: coarse and tracking tip-withdrawal, as illustrated in Fig. 1. The deposition profiles in Fig. 2 demonstrate that tracking tip-withdrawal scheme results in a lower deposition levels around the base, thus producing a more confined geometry. The second investigated factor is the shape of the electrode tip, where solid-end electrode and tapered-end electrode geometries are considered, as shown by the photographs in Fig. 3. The resulting deposition profile, calculated in Fig. 3, demonstrate that tapered-end electrode results in a more defined deposition boundaries and even lower deposition level around the base.

EXPERIMENTAL RESULTS

Based on the above analysis, the deposition of copper columns was attempted using a combination of a coarse tip-withdrawal along with a solid-end electrode, and a tracking tip-withdrawal along with a tapered-end electrode. The deposition results of the cases are shown in the SEM images in Fig. 4. The results clearly demonstrates a much better confined geometry of the deposition, even at the base, using the tracking tip-withdrawal control scheme and a tapered-end electrode.

ACKNOWLEDGMENT

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REFERENCES

1. C. A. Brebbia, The Boundary Element Method for Engineers, Pentech Press, 1984.

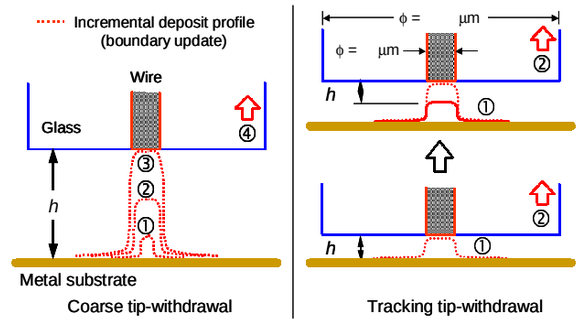


Fig. 1: Schematics of the calculation steps performed in the progressive boundary updating method, simulating a coarse tip-withdrawal control and a tracking tip-withdrawal one.

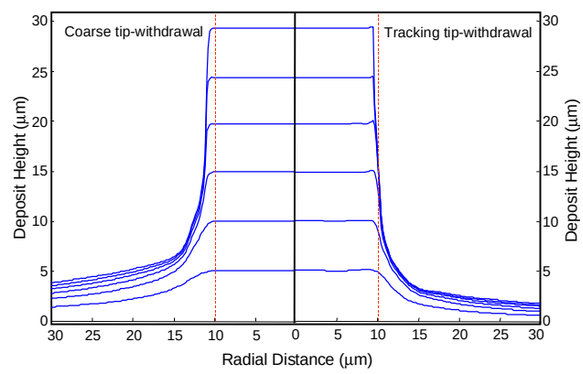


Fig. 2: Evaluated deposition profiles for the coarse and tracking tip-withdrawal scenarios.

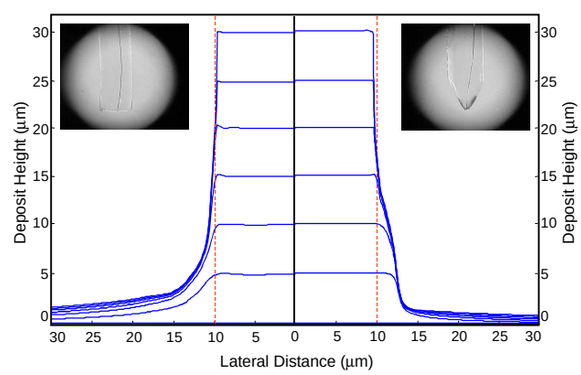
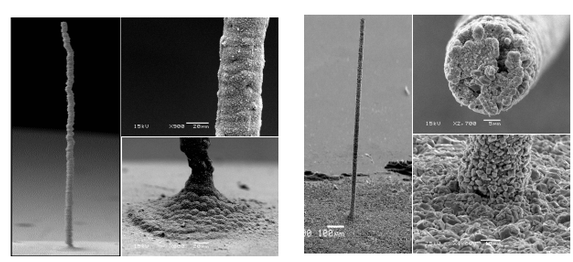


Fig. 3: Evaluated deposition profiles using a solid-end electrode (left) and a tapered-end electrode (right), both calculated considering a tracking tip-withdrawal scenario.



(a) (b)

Fig. 4: SEM images of copper column structures deposited using: (a) a coarse tip-withdrawal control along with a solid-end electrode, and (b) a tracking tip-withdrawal control along with a tapered-end electrode.