

# Filling of nanoscale holes with high aspect ratio by Cu electroplating using suspension of supercritical carbon dioxide in electrolyte with Cu particles

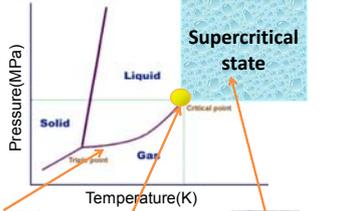
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## Introduction

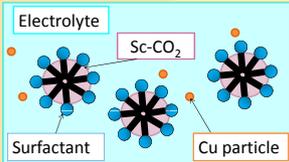
### Supercritical carbon dioxide (sc-CO<sub>2</sub>)



Low density & viscosity & surface tension

Available carriage of materials to microstructure

### Sc-CO<sub>2</sub> suspension

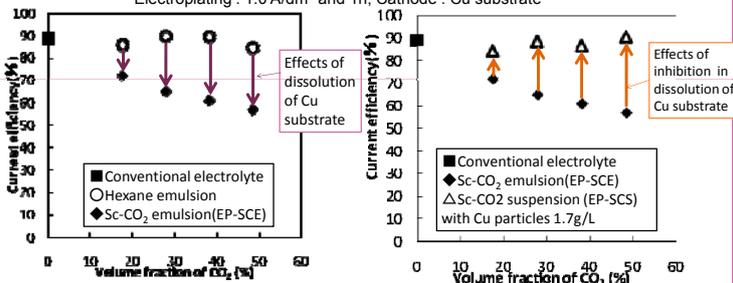


- Sc-CO<sub>2</sub> is non-polar → Make the emulsion
- Desorption of H<sub>2</sub> from cathode → Void- and pinhole-free
- Cu particles in the emulsion → Make the suspension

## Results and Discussion

### Current efficiency

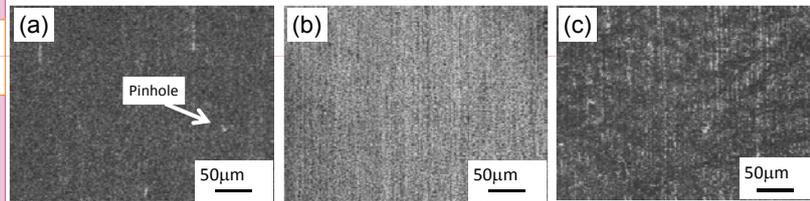
Electroplating : 1.0 A/dm<sup>2</sup> and 1h, Cathode : Cu substrate



- Current efficiency of sc-CO<sub>2</sub> emulsion (EP-SCE) is lower than hexane emulsion
- Cu substrate dissolved in sc-CO<sub>2</sub> emulsion
- Current efficiency of EP-SCS is higher than scCO<sub>2</sub> emulsion
- Cu particles inhibited dissolution of Cu substrate

### Morphology of Cu films

Electroplating : 1.0 A/dm<sup>2</sup> and 10min, Cathode : Cu substrate

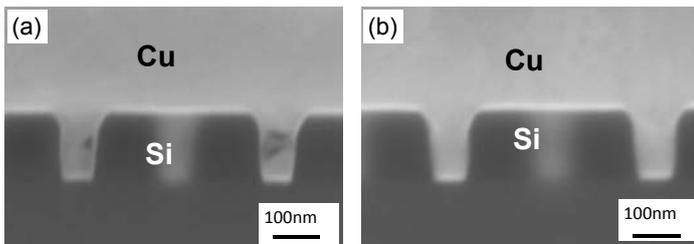


- Cu film by conventional method is smooth, but **pinholes are found**
- Cu film by EP-SCE is smooth and **with no pinhole**
- Cu film by EP-SCS is smooth and **with no pinhole**
- **Cu particles dissolved in the electrolyte**

## Filling of Cu with holes of 70 nm in diameter

### Aspect ratio of 2

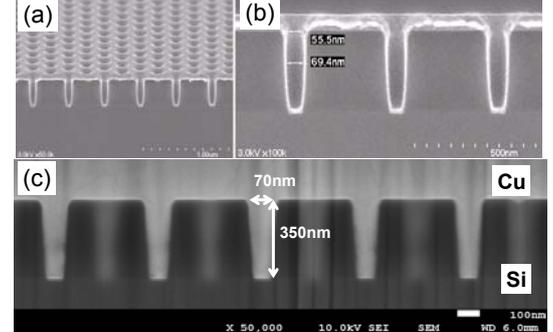
Electroplating : 1.0 A/dm<sup>2</sup> and 10min, Cathode : TEG



- Filling of Cu by conventional method is **not completed with many voids**
- Filling of Cu by EP-SCS is completed **with no void**

### Aspect ratio of 5

Electroplating : 1.0 A/dm<sup>2</sup> and 10min, Cu particles : 0.6g/L, Cathode : TEG



- Filling of Cu by EP-SCS is completed **with no void** in holes of **70 nm in diameter with aspect ratio 5**

## Conclusion

- We reported filling of nanoscale holes with high aspect ratio by Cu electroplating with the supercritical carbon dioxide suspension (EP-SCS). Current efficiency of EP-SCS increased by inhibition in dissolution of Cu substrate. The Cu film by EP-SCS method was smooth, because Cu particles dissolved in the electrolyte.
- Nanoscale holes with 70 nm in diameter and aspect ratio of 2 and 5 can be filled by electrodeposited Cu with no void and pinhole using EP-SCS because of low viscosity and high diffusivity of the sc-CO<sub>2</sub> emulsion.

## Acknowledgement

Funding Program for Next Generation World-leading Researchers (NEXT Program) GN037, Cabinet Office (CAO), Japan