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LETTER

Preparation of Si powder thick films by low frequency alternating electrophoretic deposition

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Introduction

Electrophoretic deposition (EPD) has recently gained increasing interest in the processing of advanced ceramic materials and coatings [1]. The EPD has the advantages of short formation time, simple deposition apparatus, low cost, flexibility in shape and size of the substrates and suitability for mass production [2, 3]. The EPD can be used for the fabrication of advanced ceramics in the form of thick or thin coatings, laminates, etc. [4]. Also this technique has been reported to be used for deposition of Si particles for fabrication of silicon thick films [5].

In this work, the preparation of Si thick films by alternating electrophoretic deposition (ACEPD) is reported for the first time. The interesting feature of ACEPD technique is the deposition of powder on the both electrodes. By using low frequency electric field, we deposited the Si particles in the gap and on the surface of the electrodes made of gold and/or graphite. The effect of frequency and the wave form on the deposit yield is reported in this article.

Experimental procedure

P-type semiconductor Si powder (Wacker Chemitronic GmbH) with the mean particle size of about 4 micron (Fritsch Particle Sizer, analysette 22) and surface area of 6.58 m^2/g (Gemini 2375) was used after washing and etching. 0.1%wt Si powder was dispersed in pure acetylaceton (MERCK art. 800023) after 30 min ultrasonic agitation. The suspension was stable for about 30 min, which was sufficient for our experiments. The media selected was of pure grade due to the importance of impurities [6].

A schematic illustration of the ACEPD cell is shown in Fig. 1. A gold-coated borosilicate sheet glass and a cylindrical carbon-coated alumina were used as depositing substrates. A gap of about 200 micron was made on the substrates by a sharp alumina tip. The leakage current of the bases at room temperature was higher than 20 MΩ.

Results

Deposition at 0.1 Hz (rectangular wave), 40 V and 10 min on the gold and the graphite bases showed that the Si particles have deposited in the gap and on the surface of the electrodes. There is no major difference between the deposition of Si powders on the gold and graphite electrodes.

The variation of deposit yield versus frequency is shown in Fig. 2. It is clear that the deposit yield decreases as the frequency of the electric field increases from 0.01 Hz to 1,000 Hz. The same trend has been reported in our previous work [7].

The shape of the waveform is another affecting parameter in ACEPD. The effect of the waveform on the deposit yield is presented in Fig. 3. Three different waveforms, i.e., rectangular (rec.), sinusoidal (sin.), and triangular (tri.) were used at two frequencies of 0.01 and 1 Hz. One can see that the deposit yield is highest at 0.01 Hz and rec. wave and the lower deposit yield has been obtained at 1 Hz and tri. wave. The deposition yield is

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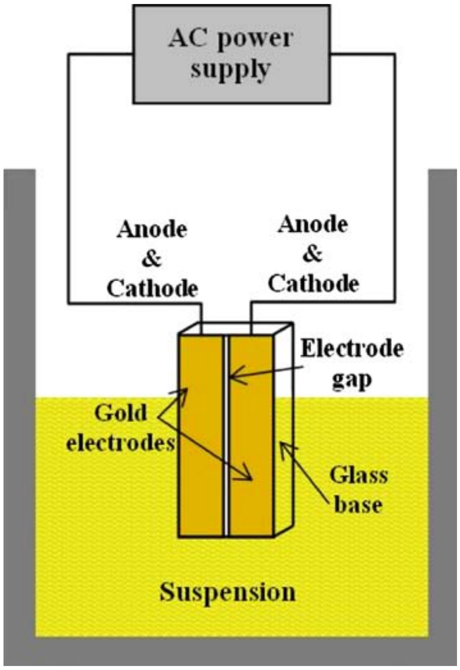

Fig. 1 Schematic illustration of the ACEPD cell

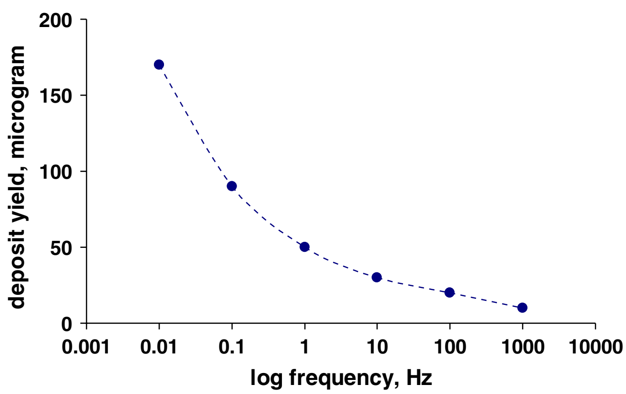

Fig. 2 Variation of deposit yield with frequency of the AC electric field at 30 V and 5 min

proportional to the effective voltage of the applied AC field, i.e., the effective voltage of the rectangular, sinusoidal, and triangular waves are 1, $\frac{\sqrt{2}}{2}$, and $\frac{1}{2}$, respectively.

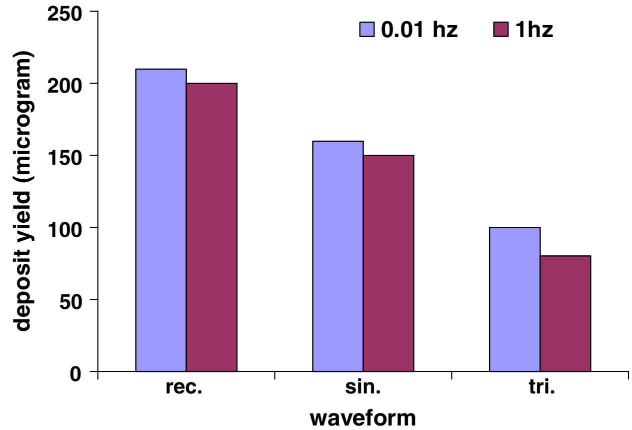

Fig. 3 Deposit yield versus three different wave forms (rectangular, sinusoidal, and triangular) at 30 V, 5 min and two frequencies of 0.01 and 1 Hz

Conclusion

Si particles have been deposited on the gold and graphite electrodes using low frequency alternating electric field. The deposition has occurred both in the gap between the electrodes and on the surface of the electrodes. The deposition yield decreases with frequency. The deposit yield also decreases as the waveform changes from rectangular to sinusoidal and then to triangular.

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