

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>(51) International Patent Classification 6 :</b><br>C25D 3/58, 3/38, 7/00, 5/02, B41M 5/20,<br>H01M 4/02, H01L 21/288, 21/445, C23C<br>28/00, 28/02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>A1</b> | <b>(11) International Publication Number:</b> <b>WO 99/47731</b><br><br><b>(43) International Publication Date:</b> 23 September 1999 (23.09.99)                                                         |
| <b>(21) International Application Number:</b> PCT/US99/06306<br><b>(22) International Filing Date:</b> 22 March 1999 (22.03.99)<br><br><b>(30) Priority Data:</b><br>09/045,245      20 March 1998 (20.03.98)      US<br>60/085,675      15 May 1998 (15.05.98)      US<br><br><b>(71) Applicant (for all designated States except US):</b> SEMITOOL,<br>INC. [US/US]; 655 Reserve Drive, Kalispell, MT 59901<br>(US).<br><br><b>(72) Inventor; and</b><br><b>(75) Inventor/Applicant (for US only):</b> CHEN, Linlin [CA/US]; 121<br>Hawthorne Avenue, Kalispell, MT 59901 (US).<br><br><b>(74) Agent:</b> ERICKSON, Randall, T.; Rockey, Milnamow & Katz,<br>Ltd., Two Prudential Plaza, 47th floor, 180 North Stetson,<br>Chicago, IL 60601 (US). |           | <b>(81) Designated States:</b> CN, JP, KR, SG, US, European patent (AT,<br>BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU,<br>MC, NL, PT, SE).<br><br>Published<br>With international search report. |

**(54) Title:** APPARATUS AND METHOD FOR ELECTROLYTICALLY DEPOSITING COPPER ON A SEMICONDUCTOR WORK-PIECE

**(57) Abstract**

This invention employs a novel approach to the copper metallization of a workpiece, such as a semiconductor workpiece. In accordance with the invention, an alkaline electrolytic copper bath (35) is used to electroplate copper onto a seed layer (30), electroplate copper directly onto a barrier layer material, or enhance an ultra-thin copper seed layer which has been deposited on the barrier layer using a deposition process such as PVD. The resulting copper layer provides an excellent conformal copper coating that fills trenches, vias, and other microstructures in the workpiece. When used for seed layer enhancement, the resulting copper seed layer provides an excellent conformal copper coating that allows the microstructures to be filled with a copper layer having good uniformity using electrochemical deposition techniques. Further, copper layers that are electroplated in the disclosed manner exhibit low sheet resistance and are readily annealed at low temperatures.

