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Silver Metallization

Stability and Reliability

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Dedicated to our ever patient,
supportive and loving wives,

Madeline, Katherine and Betty

Preface

Silver (Ag) is considered as a future interconnect material for ultra large scale integrated (ULSI) circuit technology, because of its low resistivity (1.6 $\mu\Omega$-cm), a value lower than that of aluminum (Al) or copper (Cu), the current choices for ULSI metallization. The drawbacks of Ag in terms of agglomeration, adhesion and corrosion are overcome by the use of encapsulation layers or addition of a few percent of alloying elements (such as Al and Ti). For example, silver with a 5% Al meets all the morphology and stability requirements for a fully processed interconnect. The advantage of silver metallization is that the complicated chemical mechanical polishing (CMP) process is not required whereas it is a crucial step in copper-based metallization.

The aim of this monograph is to provide current and up-to-date knowledge on silver metallization and its potential as a favorable candidate for implementation as a future interconnect material for integrated circuit technology. A special feature of the monograph is the presentation of novel approaches to overcome the thermal and electrical stability issues associated with silver metallization. Given the fact that silver is just now considered for manufacturing, the main benefit of the text is that it provides a valuable resource in this emerging field.

It introduces the academic community and industrial users to the subjects of preparation and characterization of elemental silver thin films and silver-metal alloys (Chapter 2); formation of diffusion barriers and adhesion promoters (Chapter 3); evaluation of the thermal stability of silver under different annealing conditions (Chapter 4); evaluation of the electrical properties of silver thin films under various processing conditions (Chapters 3 and 4); silver electromigration resistance (Chapter 5) and the integration of silver with low-k dielectric materials (Chapter 6). The monograph will be very useful to senior undergraduate and postgraduate students, scientists, engineers, and technologists in the field of integrated circuits and microelectronics research and development.

The content of the monograph is an indirect result of extensive and in-depth research and contributions by graduate students from both the Department of Physics, University of the Western Cape (UWC), Bellville, South Africa (Gerald Malgas and Basil Julies) and School of Materials Science, Arizona State University (ASU), Tempe, USA (Yu Wang, Peter Zeng, Hunckul Kim, Li Zhou,

Phucanh Nguyen, Esra Misra, Martin Mittan and Kastub Gadre). The authors acknowledge with gratitude the contributions by all these students. A special word of thanks and appreciation goes to Gerald Malgas (my first PhD student at UWC) for his assistance with the figures and drawings.

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