Advanced Interconnect Materials for 65nm Through 32nm Nodes

Prepared by

S. Holland, Ph.D., R. Geffken, Ph.D. and

K. Holland, Ph.D.

Techcet Group, LLC

August 2007 Update

775-783-8180

*** www.techcet.com**

TABLE OF CONTENTS

PAGE #

1 BACKGROUND AND TECHNOLOGY OVERVIEW 4
1.1 Interconnect Trends 5
1.2 Factors Driving the Change from Al to Cu wiring 8
1.3 Interconnect Processes 10
1.4 Process Flows for Interconnect by IC Product and Generation 12
1.5 Roadmap Implications... 18
1.6 Process Flows.. 28

2 INTERCONNECT PROCESS MATERIAL DESCRIPTIONS 32
2.1 Poly-Metal Dielectric (PMD) 32
2.2 Metal Filled Contact Plugs... 32
2.3 Metal for Interconnect Wiring 33
2.4 Integrated Barrier Seed, PVD... 34
2.5 Copper Cap after CMP.. 34
2.6 Inter-Level Dielectric (ILD) 35

3 INTERCONNECT MATERIALS FORECAST MARKET SIZES 38
3.1 Poly-Metal Dielectric (PMD) 38
3.2 Metal Filled Contact Plugs.. 39
3.3 Barrier Metal for Copper Wiring... 41
3.4 Metal for Interconnect Wiring 43
3.5 Copper Cap and Cap Barrier Dielectric 44
3.6 Inter-Metal Dielectric (IMD), Including Spin-On Low k 45

FIGURES

PAGE #

Figure 1: Percentage of Wafers by Technology with Cu Interconnects. 6
Figure 2: Circuit Delay as a Function of Feature Size.. 8
Figure 3: RC Delay, Cu, & Low κ 9
Figure 4: Al Wire with Oxide Dielectric.. 11
Figure 5: Cu Dual Damascene with Oxide Dielectric 11
Figure 6: Process Sequence for Cu Dual Damascene.. 12
Figure 7: Process Sequence for ICs from PMD through W Plug Fill of Contacts.......... 13
Figure 8: Process Sequence for Al-Cu ICs, All Metal Layers Processed Similarly 14
Figure 9: Process Sequence for Copper Wiring ICs for First Metal Formation............. 15
Figure 10: Process Sequence for Copper ICs for Each Metal Level Beyond M1........... 16
Figure 11: Process Sequence Options for Copper Wiring 17
Figure 12: κ_{eff} Roadmap Delay as Explained in the 2003 ITRS................................ 24
Figure 13: 65 nm Potential Integration Schemes 26

 Copyright 2007 Techcet Group, LLC

Figure 14: Detailed Hybrid Insulator Stack 36
Figure 15: Drawings of Alternative ILD Stacks 36
Figure 16: Revenue Forecast for Spin-On Gapfill for PMD (graph and following table) 38
Figure 17: Spin-On Gapfill for PMD in Volumes (graph and following table).......... 39
Figure 18: Revenue Forecast for Only WF_6 at 90nm through 32nm 40
Figure 19: Revenue Forecast for Only TDMAT at 90nm through 32nm nodes 40
Figure 20: Amount of TDMAT used for CVD Ti of 90nm through 32 nm Nodes 41
Figure 21: Ta Barrier Sputter Target Revenues.......... 42
Figure 22: ALD Metal Barrier Forecast 42
Figure 23: Copper Plating Bath Revenue Projections 43
Figure 24: Copper Plating Bath Volume Projections.......... 43
Figure 25: Revenue Opportunity for CoWP or CoWB 45
Figure 26: Revenue Forecast for CVD Low k Precursors 46
Figure 27: Volume Forecast for CVD Low k Precursors 46
Figure 28: Revenue and Volume Forecast for Spin-On Low k Materials 48
Figure 29: Revenue and Volume Forecast for Spin-On Low k Materials 48

TABLES

PAGE #

Table 1: Materials & Process Options for 2007 (65 nm) & 2010 (45 nm).......... 7
Table 2: Properties of Metals 9
Table 3: 2006 ITRS for MPUs (Near-Term Years).......... 20
Table 4: 2006 ITRS for DRAMs (Near-Term Years) 23
Table 5: 2006 ITRS, Interconnect Difficult Challenges for Advanced Dielectrics 27
Table 6: Process Flow for MPU and ASIC Products 65 nm to 32 nm Nodes.......... 29
Table 7: Process Flow for DRAM and Memory Products 65 nm to 32 nm Nodes.......... 30
Table 8: Process Flow for Flash and NAND Products 65 nm to 32 nm Nodes 31
Table 9: CVD Precursors by Technology Node from 2005 ITRS 37
Table 10: Precursors and Their Chemistry.......... 37
Table 11: Precursors and Their OEMs 38
Table 12: Revenue Forecast for the amount of 3MS used for Cu Cap 47

Readers note: this report represents the interpretation and analysis of information generally available to the public or released by responsible agencies or individuals. Data was obtained from sources considered reliable. However, accuracy or completeness is not guaranteed.

 Copyright 2007 Techcet Group, LLC