US007186653B2

(12) **United States Patent**
Jha et al.

(10) **Patent No.: US 7,186,653 B2**
(45) **Date of Patent: Mar. 6, 2007**

(54) **POLISHING SLURRIES AND METHODS FOR CHEMICAL MECHANICAL POLISHING**

(75) Inventors: **Sunil Chandra Jha**, Oro Valley, AZ (US); **Sreehari Nimmala**, Oro Valley, AZ (US); **Sharath Hegde**, Potsdam, NY (US); **Youngki Hong**, Potsdam, NY (US); **Suryadevera V. Babu**, Potsdam, NY (US); **Udaya B. Patri**, Potsdam, NY (US)

(73) Assignee: **Climax Engineered Materials, LLC**, Phoenix, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 113 days.

(21) Appl. No.: **11/032,717**

(22) Filed: **Jan. 11, 2005**

(65) **Prior Publication Data**

US 2005/0211953 A1 Sep. 29, 2005

Related U.S. Application Data

(63) Continuation-in-part of application No. 10/846,718, filed on May 13, 2004, which is a continuation-in-part of application No. 10/631,698, filed on Jul. 30, 2003.

(51) **Int. Cl.**
H01I 21/302 (2006.01)
C09K 13/00 (2006.01)

(52) **U.S. Cl.** **438/692**; 252/79.1

(58) **Field of Classification Search** 438/692; 252/79.1

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,958,288	A	9/1999	Mueller et al.	
5,996,594	A *	12/1999	Roy et al.	134/1.3
6,143,656	A	11/2000	Yang et al.	
6,348,076	B1	2/2002	Canaperi et al.	
6,358,853	B2	3/2002	Cadien et al.	
6,511,912	B1 *	1/2003	Chopra et al.	438/674
6,520,840	B1	2/2003	Wang et al.	
6,530,968	B2	3/2003	Tsuchiya et al.	
6,544,892	B2	4/2003	Srinivasan et al.	
6,558,570	B2	5/2003	Alwan et al.	
6,561,883	B1 *	5/2003	Kondo et al.	451/63
6,569,350	B2	5/2003	Kaufman et al.	
6,585,568	B2	7/2003	Tsuchiya et al.	
6,585,786	B2	7/2003	Tsuchiya et al.	
6,589,099	B2	7/2003	Haggart, Jr. et al.	
6,726,990	B1	4/2004	Kumar et al.	
6,758,872	B2 *	7/2004	Ota et al.	51/307
2002/0098701	A1 *	7/2002	Hasegawa	438/692
2003/0047710	A1	3/2003	Babu et al.	
2003/0092271	A1	5/2003	Jindal et al.	

OTHER PUBLICATIONS

Aramaki et al., 1991, "Surface Enhanced Raman Scattering and Impedance Studies on the Inhibition of Copper Corrosion in Sulphate Solutions by 5-Substituted Benzotriazoles," *Corrosion Science*, 32(5/6):593-607.

Aveston et al., 1964, "Hydrolysis of Molybdenum(VI). Ultracentrifugation, Acidity Measurements, and Raman Spectra of Polymolybdates," *Hydrolysis of Molybdenum (VI)*, 3(5):735-746.

Bhuvanesh et al., 1997, "Solid-state chemistry of early transition-metal oxides containing d^0 and d^1 cations," *J. Mater. Chem.*, 7(12):2297-2306.

Busey et al., 1964, Structure of the Aqueous Pertechnetate Ion by Raman and Infrared Spectroscopy. Raman and Infrared Spectra of Crystalline $KTcO_4$, KReO4, Na2MoO$_4$, Na_2WO_4, Na_2MoO_4•$2H_2O$, and Na_2WO_4•SH2O, *J. Chem. Physics*, 41(1):215-225.

Du et al., 2004, "Electrochemical characterization of copper chemical mechanical planarization in KIO_3 slurry," *Applied Surface Science*, 229:167-174.

Gutmann et al., 1995, "Chemical-mechanical polishing of copper with oxide and polymer interlevel dielectrics," *Thin Solid Films*, 270:596-600.

Hariharaputhiran et al., 2000, "Chemical Mechanical Polishing of Ta," *Electrochemical and Solid-State Letters*, 3(2):95-98.

Hegde et al., 2003, "Removal of Shallow and Deep Scratches and Pits from Polished Copper Films," *Electrochemical and Solid-State Letters*, 6(10):G126-G129.

Jindal et al., 2002, "Chemical Mechanical Polishing Using Mixed Abrasive Slurries," *Electrochemical and Solid-State Letters*, 5(7):G48-G50.

Jindal et al., 2003, "Chemical Mechanical Polishing of Dielectric Films Using Mixed Abrasive Slurries," *J. of the Electrochemical Society*, 150(5):G314-G318.

Kallay et al., 1985, "Adsorption at Solid/Solution Interfaces. 1. Interpretation of Surface Complexation of Oxalic and Citric Acids with Hematite," 1(2):195-201.

Kamigata et al., 2001, "Why abrasive free Cu slurry is promising," *Mat. Res. Soc. Symp. Proc.*, 671:M1.3.1-M1.3.12.

Kaufman et al., 1991, "Chemical-Mechanical Polishing for Fabricating Patterned W Metal Features as Chip Interconnects," *J. Electrochem. Soc.*, 138(11):3460-3465.

(Continued)

Primary Examiner—Nadine Norton
Assistant Examiner—Lynette T. Umez-Eronini
(74) *Attorney, Agent, or Firm*—Bruce E. Dahl, Esq.; Dahl & Osterloth, LLP

(57) **ABSTRACT**

Aqueous polishing slurries for chemical-mechanical polishing are effective for polishing copper at high polish rates. The aqueous slurries according to the present invention may include soluble salts of molybdenum dissolved in an oxidizing agent and molybdic acid dissolved in an oxidizing agent. Methods for polishing copper by chemical-mechanical planarization include polishing copper with low pressures using a polishing pad and a aqueous slurries including soluble salts of molybdenum dissolved in an oxidizing agent and molybdic acid dissolved in an oxidizing agent, particles of MoO_3 dissolved in an oxidizing agent, and particles of MoO_2 dissolved in an oxidizing agent.

2 Claims, No Drawings