

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

(19) World Intellectual Property
Organization
International Bureau

(43) International Publication Date
25 February 2021 (25.02.2021)



(10) International Publication Number
WO 2021/035236 A1

(51) International Patent Classification:

H01L 21/285 (2006.01) *C23C 16/455* (2006.01)
C23C 16/30 (2006.01) *C23C 16/06* (2006.01)
H01L 21/28 (2006.01) *H01L 21/027* (2006.01)
H01L 21/768 (2006.01)

(21) International Application Number:

PCT/US2020/070390

(22) International Filing Date:

10 August 2020 (10.08.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/890,456 22 August 2019 (22.08.2019) US

(71) Applicant: **LAM RESEARCH CORPORATION**

[US/US]; 4650 Cushing Parkway, Fremont, California 94538 (US).

(72) Inventors: **BLAKENEY, Kyle Jordan**; 4650 Cushing

Parkway, Fremont, California 94538 (US). **LAI, Chiukin Steven**; 4650 Cushing Parkway, Fremont, California 94538 (US). **PRATT, Thomas M.**; 4650 Cushing Parkway, Fremont, California 94538 (US). **LENZ, Eric H.**; 4650 Cush-

ing Parkway, Fremont, California 94538 (US). **STEVENS, Jason**; 4650 Cushing Parkway, Fremont, California 94538 (US).

(74) Agent: **GAVRILOVA, Anna** et al.; Weaver Austin Villeneuve & Sampson LLP, P.O. Box 70250, Oakland, California 94612-0250 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,

(54) Title: SUBSTANTIALLY CARBON-FREE MOLYBDENUM-CONTAINING AND TUNGSTEN-CONTAINING FILMS IN SEMICONDUCTOR DEVICE MANUFACTURING

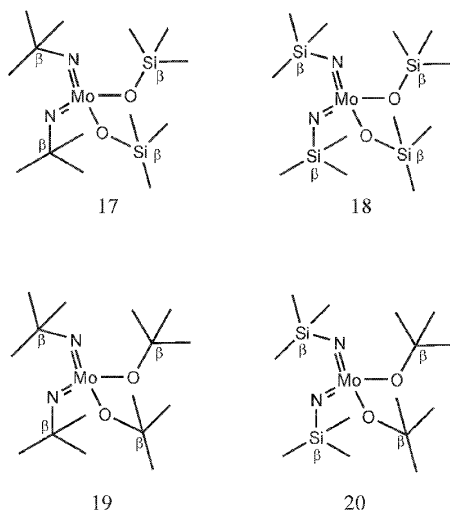


Figure 1B

(57) Abstract: Substantially carbon-free molybdenum-containing and tungsten-containing films are deposited on semiconductor substrates using halide-free metalorganic precursors. The precursors do not include metal-carbon bonds, carbonyl ligands, and, preferably do not include beta-hydrogen atoms. Metal-containing films, such as molybdenum nitride, molybdenum oxynitride, molybdenum silicide, and molybdenum boride with carbon content of less than about 5% atomic, such as less than about 3% atomic are deposited. The films are deposited in some embodiments by reacting the metal-containing precursor with a reactant on a surface of a substrate in an absence of plasma, e.g. using several ALD cycles. In some embodiments the formed film is then treated with a second reactant in a plasma to modify its properties (e.g., to densify the film, to reduce resistivity of the film, or to increase its work function). The films can be used as liners, diffusion barriers, and as electrode material in pMOS devices.

[Continued on next page]

MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*