

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Roy G. GORDON et al.	Confirmation No.:	2276
Application No.:	11/199,032	Art Unit:	1621
Filed:	August 8, 2005	Examiner:	G. P. Nazario
Title:	VAPOR DEPOSITION OF METAL OXIDES, SILICATES AND PHOSPHATES, AND SILICON DIOXIDE		

DECLARATION UNDER 37 C.F.R. §1.132

I, Roy Gordon, hereby declare as follows:

1. I am a co-inventor of the above-referenced patent application.
2. I received my bachelor of arts (A.B) in chemistry and physics (summa cum laude) in 1961 from Harvard College, my master of arts (A.M.) in physics in 1962 from Harvard University, and my doctor of philosophy (Ph.D.) in chemical physics in 1964 from Harvard University.
3. I am the Thomas D. Cabot Professor of Chemistry at Harvard University. I have been working at Harvard University since 1964, serving as chairman of the Chemistry department between 1992-1995.
4. I have been elected to the National Academy of Sciences in 1985, the American Academy of Arts and Sciences in 1976, the European Academy of Arts, Sciences and Humanities in 1984, and am a fellow of the American Chemical Society and the American Physical Society, and was chairman of its Division of Chemical Physics.

5. I have been working on precursors for vapor deposition since 1974 and consider myself to be generally aware of the scientific and commercial activities regarding the claimed $\text{Hf}(\text{NEtMe})_4$.
6. I have personal contacts with various chemical suppliers and semiconductor manufacturers that supply or use precursors for vapor deposition. These personal contacts allow me access to certain information that is not published in scientific literature or industry publications.
7. The statements made herein are based upon my current understanding of the scientific literature, industry publications, and correspondences with my personal contacts noted above.
8. In my opinion, as explained more fully below, the claimed $\text{Hf}(\text{NEtMe})_4$ solves a long-felt need of the semiconductor industry and has achieved commercial success after the effective filing date of the present application (September 28, 2000) and the publication of the parent PCT/US/01/30507 (April 4, 2002).

A. Use in semiconductor industry as precursors for depositing high-dielectric gate material

9. Silicon dioxide has been used for decades as the dielectric material of choice in semiconductor fabrication processes. With miniaturization of electronic devices, corresponding decrease in the thickness of the silicon dioxide dielectric material was needed. However, as the thickness of the silicon dioxide decreases, problems emerged. For example, when silicon dioxide was used as the gate layer in transistors, leakage currents tunneling through the gate material led to large power consumption and lowered device reliability.

10. Additional problems are encountered when forming dielectric materials in deep trench structures, such as dynamic random access memory (DRAM) devices. Not only must the capacitance values remain at certain level despite the reduction in size, the precursors must be delivered deep into the trenches without premature reaction that precludes uniform coverage within the entire deep trench structure.
11. In my opinion, the search for suitable high-dielectric material and suitable precursors to deposit such high-dielectric material emerged at least by the early to mid 1990s. In support of this opinion, I attach in **Exhibit A** an Abstract from the Proceedings of Advanced Metallization and Interconnect Systems for ULSI Applications, showing that silicon dioxide was considered a “conventional” dielectric, and that scientists have been searching for suitable high-dielectric precursors/materials for deep trench structure at least since 1996.
12. No solution for putting high dielectric material into deep trenches was even expected until 2008. In support of this, I attach in **Exhibit B** the 2000 International Technology Roadmap for Semiconductors (ITRS). ITRS is a set of documents produced by a group of semiconductor industry experts, and is meant to represent the best opinion of these experts on the directions of research up to about 15 years into the future. As shown in **Exhibit B**, high dielectric material for the year 2008 is highlighted, indicating no satisfactory working solution existed as of 2000 and the roadmap is working towards a solution to occur by year 2008. In other words, near the effective filing date of the present application, group of semiconductor industry experts believed that the high-dielectric material problem would not be solved for at least another eight years.

13. Nevertheless, after the parent PCT/US/01/30507 published in April 4, 2002, I understand that high dielectric material went into production for DRAM at least by 2006. This is at least two years before the date expected by a group of semiconductor industry experts.
14. I have heard from my personal contacts in various industry settings that the claimed $\text{Hf}(\text{NEtMe})_4$ precursor is now being widely used to produce high dielectric materials in DRAM structures.
15. In fact, as shown in a recent print out from <http://www.commerce.com.tw> (see **Exhibit C**), vapor deposition precursor vendors are noting that the claimed $\text{Hf}(\text{NEtMe})_4$ (abbreviated as TEMAH therein) is now being “widely used in semiconductor industry.”
16. In my opinion, based on the foregoing information, I believe that the claimed $\text{Hf}(\text{NEtMe})_4$ solved a long-felt need in the semiconductor industry for suitable high-dielectric material precursors, is currently being used as a precursor to prepare high dielectric materials, and has achieved widespread commercial success.

B. Commercial sales of the claimed $\text{Hf}(\text{NEtMe})_4$

17. Moreover, as part of my ordinary course of scientific research, I routinely review chemical supplier catalogues to purchase necessary chemicals and to learn what new compounds are currently being offered for sale.
18. I was and am not aware of a single vendor who was selling or offering to sell the claimed $\text{Hf}(\text{NEtMe})_4$ before the effective filing date of the present application (September 28, 2000).

Despite the fact that $\text{Hf}(\text{NEt}_2)_4$ and $\text{Hf}(\text{NMe}_2)_4$ were known since 1969 (see Table 1 of instant specification), I am not aware that any commercial sales of the claimed $\text{Hf}(\text{NEtMe})_4$ took place as of the effective filing date of the present application.

19. After the effective filing date of the application, I disclosed the claimed $\text{Hf}(\text{NEtMe})_4$ precursor to at least one chemical supplier under a confidentiality agreement. Subsequently, I observed offers for sale of the claimed $\text{Hf}(\text{NEtMe})_4$ precursor by chemical suppliers.

20. As of June 2008, I am aware of at least 19 companies, listed below, that are selling the claimed $\text{Hf}(\text{NEtMe})_4$. The ChemAbstracts database printout indicating offer for sale from the following vendors and the printout of available website pages showing such sales or offer for sale (12 of 19 were retrieved as shown in **Exhibit D**) are also attached herewith.

- Adeka Corporation (attached)
- Advanced Technology & Industrial Co., Ltd. (attached)
- Advanced Technology Materials, Inc.
- Air Liquide (attached)
- Air Products and Chemicals (attached)
- Alfa Aesar (attached)
- Central Glass Company, Ltd.
- Dalchem
- Digital Specialty Chemicals, Inc. (attached)
- Frontier Chemicals (attached)
- Gelest, Inc. (attached)
- Nanmat Technology Co., Ltd. (attached)
- Praxair Electronics (attached)

- Rohm and Haas
- Sigma-Aldrich Company (attached)
- SinoChemexper Company
- Tosoh
- Tri Chemical Company
- UP Chemical Co., Ltd. (attached)

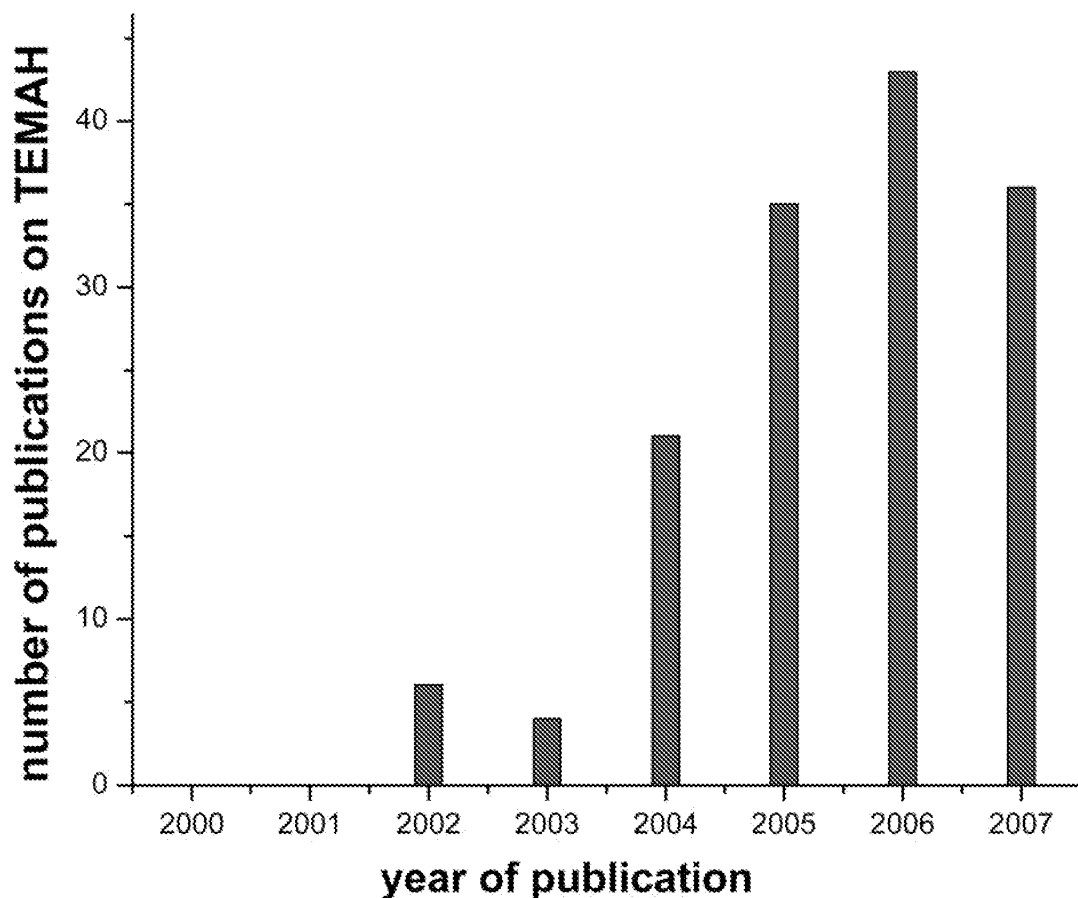
21. In my opinion, based on the foregoing information, I believe that the claimed $\text{Hf}(\text{NEtMe})_4$ has achieved widespread commercial success.

C. Increased scientific study of the claimed $\text{Hf}(\text{NEtMe})_4$

22. In addition, the increased commercial sales of the claimed $\text{Hf}(\text{NEtMe})_4$ between 2000 and 2008 was accompanied by a similar increase in the number of scientific publications of the claimed compound. Shown below is a plot of the number of scientific publications that explicitly mention $\text{Hf}(\text{NEtMe})_4$ as a function of the year of publication. This plot was obtained by searching the ChemAbstracts database using the chemical structure of $\text{Hf}(\text{NEtMe})_4$ as the input. It is my understanding that the ChemAbstracts database searches for publications within at least the last century.

23. As shown, markedly increased study into the claimed $\text{Hf}(\text{NEtMe})_4$ is noticeable after the corresponding PCT/US01/30507 published on April 4, 2002 and Hausmann et al., “Atomic layer deposition of hafnium and zirconium oxides using metal amide precursors,” Chem. Mater., Vol. 14, pp. 4350-4358 (2002), for which I am a co-author. In fact, not one single

scientific publication explicitly mentioning $\text{Hf}(\text{NEtMe})_4$ on or before the effective filing date of the present application (September 28, 2000) was found by the ChemAbstracts database.



24. Moreover, to date, 85 citations have been made (see **Exhibit E**) to Hausmann et al., “Atomic layer deposition of hafnium and zirconium oxides using metal amide precursors,” Chem. Mater., Vol. 14, pp. 4350-4358 (2002). In my opinion, the high number of citations since this paper has published is further evidence that the claimed $\text{Hf}(\text{NEtMe})_4$ has received much scientific interest.

25. In my opinion, based on the foregoing information, I believe that such increased interest in the claimed $\text{Hf}(\text{NEtMe})_4$ is another indication that the claimed $\text{Hf}(\text{NEtMe})_4$ achieved widespread commercial success.

Conclusion

26. In summary, based on the foregoing information, it is my opinion that the claimed $\text{Hf}(\text{NEtMe})_4$ solves a long-felt need in the semiconductor industry for suitable high-dielectric material precursors and the claimed $\text{Hf}(\text{NEtMe})_4$ has achieved widespread commercial success.

27. I further declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that the making of willfully false statements and the like is punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Inventor: Roy Gordon

Signed: 

Dated: August 12, 2008

Exhibit A

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1 page(s) will be printed.

Record: 1

Title: High-K dielectrics for DRAM applications

Authors: Furumura, Y.¹

Editors: Havemann, R.; Schmitz, J.; Koriyama, H.; Tsubouchi, K.

Author's Affiliation: ¹Fujitsu Labs. Ltd., Kawasaki Japan

Source: Advanced Metallization and Interconnect Systems for ULSI Applications in 1996 1997, pp., pp. 401-7, xvi+606 pp., Pittsburgh, PA, USA; Boston, MA, USA: Mater. Res. Soc.

Language: English

Conference Information: Proceedings of Advanced Metallization and Interconnect Systems for ULSI Applications in 1996. Boston, MA, USA, 19961001

Abstract: A certain capacitance must be maintained in spite of the cell reduction in DRAMs. This contradiction has been solved by introducing 3-dimensional structures such as fin-type capacitors or trench capacitors. However, it is difficult to satisfy the capacitance requirements of C-bit DRAMs using conventional dielectrics like SiO₂/sub 2/ or ONO. For this reason, recently, high-dielectric (high-K) materials such as Ta₂O₅/sub 5/ or (Ba,Sr)TiO₃/sub 3/, have been gathering much attention to obtain sufficient capacitance with a small cell size. Ta₂O₅/sub 5/ is a promising material for 256-Mbit to 1-Gbit DRAMs. (Ba,Sr)TiO₃/sub 3/ can be applied to DRAMs beyond 1-Gbit. Processes that do not degrade high-K materials are needed. *Abstract Numbers:* B1998-12-2810-003

Inspec Headings: barium compounds; dielectric thin films; DRAM chips; MIS capacitors; tantalum compounds

Key Phrase Headings: high-K dielectrics; DRAM applications; capacitance; 3-dimensional structure; fin-type capacitors; trench capacitors; cell size; 256 Mbit; 1 Gbit; Ta₂O₅/sub 5/; BaSrTiO₃/sub 3/

Classification: B2810 Dielectric materials and properties
B2130 Capacitors
B2530F Metal-insulator-semiconductor structures
B1265D Memory circuits
B2570 Semiconductor integrated circuits

Treatment: Experimental

Numerical Data: storage capacity 2.68E+08 bit; storage capacity 1.1E+09 bit (help)

Chemicals: Ta₂O₅/bin Ta₂/bin O₅/bin Ta/bin O/binBaSrTiO₃/ss TiO₃/ss Ba/ss O₃/ss Sr/ss Ti/ss O/ss

Number of References: 8

Publication Type: Conference Paper

Update Code: 1998043

Accession Number: 6067693

Copyright Information: Copyright 1998, IEEE

Database: Inspec

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Exhibit B

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2000 UPDATE										
YEAR OF PRODUCTION TECHNOLOGY NODE (1999 ITRS)	1999 180 nm	2000	2001	2002 130 nm	2003	2004	2005 100 nm	2006 70 nm	2011 50 nm	2014 35 nm
YEAR OF PRODUCTION TECHNOLOGY NODE (PROPOSED NODE YEARS ARE NOW 2007/65nm; 2010/45nm; 2013/32nm; 2016/23nm) (SC. 2.0)	1999 180 nm	2000	2001 130 nm	2002	2003	2004 90nm	2005	2006 [60 nm]	2011 [40 nm]	2014 [30 nm]

Table36 DRAM Trench Capacitor Films Technology Requirements**

Year of First Product Shipment Technology Node	1999 180 nm	2002 130 nm	2005 100 nm	2008 70 nm	2011 50 nm	2014 35 nm
DRAM Half-Pitch (nm)	180	130	100	70	50	35
DRAM Half-Pitch proposed for 2001 ITRS (nm) (A)	180	115	80	60	40	30
Storage node rows, top view [(DRAM 1/2 pitch) ²]	2	2	2	<2	<2	<2
Trench structure	conventional	bottled	bottled	bottled	tbd.	tbd.
Trench area enhancement factor	1	1.5	2	2	1.5	1.5
Capacitor dielectric equivalent oxide thickness (nm)	4.5	3.5	3.2	1.5	1	1/2
Trench depth [µm], (at 3σ)	5-7	5-6	5-6	4-5	4-5	4-5
Aspect ratio (trench depth / trench width)	30-40	40-45	50-60	60-70	>70	>100
Upper electrode	Silicon	Silicon	Silicon	Metal	Metal	Metal
Dielectric material	NO	NO	NO	High-k	High-k	High-k
Bottom electrode	Silicon	Silicon	Silicon	Silicon	Metal	Metal

(A) In response to observed acceleration of DRAM 1/2 Pitch scaling, new proposed values are presented here for year 2001 updating. Table 36 above has not been updated to reflect these new proposed values.

** In response to the observed acceleration of the Technology Nodes (TN) represented by DRAM half-pitch, the IRC proposes a new TN called Scenario 2 (SC. 2.0) for the year 2001 Renewal. However, due to the lack of time the subsequent contents of this Table are not updated to reflect the new TN.

All modifications of the items and/or numericals modified from the 1999 ITRS are based on the TN of ITRS 1999 and are highlighted in bold blue text.

Exhibit C



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TDMAH, TEMAH, TEMAZ, TAETO, TMCTS, 4MS, DMDMOS & OMCTS (99.9999% ~ 99.999999% (6N ~ 7N5

Category :
Chemicals-chemical industrial materials






Product Specification

Packing	400g, 500AL, 1000AL
----------------	---------------------

Product Detail

These precursors are widely used in semiconductor industry, including TDMAH, TICI4, TAETO, TEMAH, TEMAZ, TBTDET, TMCTS, 4MS, DMDMOS, OMCTS and many other metals, oxides and nitrides

Precursors: The purity of these chemicals can be as high as 6N ~ 7N5(99.9999% ~ 99.999999% metal purity).

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US1DOCS 6781683v1

HARVARD Ex. 2107, p.11

Exhibit D

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SEMICONDUCTOR PRODUCTS

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- ◆ [Etching gases](#)

<http://www.adeka.co.jp/en/chemical/products/semicon/index.html> (1 of 6)8/6/2008 2:51:25 PM

SEMICONDUCTOR PRODUCTS : ADEKA

- ▶ [ALD/CVD Precursors](#)
- ▶ [MOD Precursors](#)

Department: ELECTRONIC MATERIALS SALES DEPARTMENT

Etching gases

We, ADEKA have been contributing to progress in semiconductor, flat panel display, and optical fiber field since we started to produce high purity chlorine in 1981. We also have been keeping excellent products quality based on distillation technique, analysis technique, container treatment technique, and keeping clean environment that developed through good relationship with our customers. As the results, we keep top market share about many products in following list.

PRODUCT NAME	USE	FORMULA
ADEKA HIGH-PURITY Chlorine	Etching Gas	Cl_2
ADEKA HIGH-PURITY Hydrogen Bromide		HBr
ADEKA HIGH-PURITY Boron Trichloride		BCl_3

▶ [PAGE TOP](#)

ALD/CVD Precursors

The appearances of new products are expected in semiconductor field because of its road map. We, ADEKA have been developing many ALD and CVD precursors as leading company of these kinds of products. Therefore, we success to develop our original sources about High-k, ferroelectric, electrode, and Cu for semiconductor field, and then we gain customer's satisfaction. These new products are produced in specialized plant. We operate all process, from synthesis to filling, in clean room. It makes to realize prompt action for customer requirements and changing the scale from trial to mass-production.

Dielectric Film&Dopant :

PRODUCT NAME	USE	FORMULA
ADEKA SUPER TEOS	Dielectric Film	$\text{Si}(\text{OC}_2\text{H}_5)_4$
ADEKA HIGH-PURITY TMB		$\text{B}(\text{OCH}_3)_3$
ADEKA HIGH-PURITY TEB		$\text{B}(\text{OC}_2\text{H}_5)_3$

<http://www.adeka.co.jp/en/chemical/products/semicon/index.html> (2 of 6)8/6/2008 2:51:25 PM

SEMICONDUCTOR PRODUCTS : ADEKA

ADEKA HIGH-PURITY TMP	Dopant	$P(OCH_3)_3$
ADEKA HIGH-PURITY TMOP		$PO(OCH_3)_3$
ADEKA HIGH-PURITY TEOP		$PO(OC_2H_5)_3$

New Materials :

PRODUCT	USE	ITEM	ELEMENT	APPEARANCE
PET				
PEN		$Ta_2O_5(Nb_2O_5)$	Ta(Nb)	Liquid
TBTDET				
TBTDEN				
Al(MMP) ₃		Al_2O_3	Al	Liquid
TMA				
Hf(MMP) ₄				Liquid
HTTB				
TDMAH		HfO_2	Hf	Solid(mp40℃)
TEMAH				Liquid
TDEAH				
Zr(MMP) ₄		ZrO_2	Zr	Liquid
ZTTB				
TEMAZ				
Si(MMP) ₄				
TDMAS	High-k	SiO_2	Si	Liquid
TEMASiH				
TICS				
Ce(OCEt ₂ Me) ₄			Ce	Liquid
Dy(EDMDD) ₃				Viscous Liquid
Dy(sBuCp) ₃			Dy	Liquid
La(EDMDD) ₃				Solid(mp150℃)
La(iPrCp) ₃		Rare earth	La	Liquid
Pr(EDMDD) ₃				Solid(mp50℃)
Pr(sBuCp) ₃			Pr	Liquid
Y(nBuCp) ₃			Y	Liquid

<http://www.adeka.co.jp/en/chemical/products/semicon/index.html> G of 8/8/2008 2:51:25 PM

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Catalogue No.	3574710
CAS Number	352535-01-4
Formula	C ₁₂ H ₃₂ HfN ₄

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Hf [O-t-Bu]₄, TDEAH, TEMAH
- Zirconium Oxide/Silicate (ZrO₂)
Zr [O-t-Bu]₄, TEMAZ, TDEAZ
- Silicate (TDMAG, TDEAS, TEMAS)
- Silicon Nitride (BTBAS)



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MATERIAL SAFETY DATA SHEET

CHEMICAL: TETRAKIS(ETHYLMETHYLAMINO)HAFNIUM

CAS #: NOT AVAILABLE
MF: C12H32N4Hf

TOXICITY HAZARDS:

NO DATA AVAILABLE

HEALTH HAZARD DATA:

ACUTE EFFECTS

MAY BE HARMFUL BY INHALATION, INGESTION, OR SKIN ABSORPTION.
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UPPER
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FIRST AID MEASURES:

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS
OF
WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS
AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL
RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS
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CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.



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Catalog #	CAS #	Name	Mol Formula	Mol Wt.
02-1507	712-76-5	4-PHENYLBENZYLAMINE, 97%	$C_8H_9CH_2NH_2$	183.25
03-1636	360-97-4	5-AMINOIMIDAZOLE-4-CARBOXAMIDE, 95%	$C_4H_6N_4O$	126.12
03-1351	13534-97-9	3-AMINO-6-BROMOPYRIDINE, 97%	$C_5H_5BrN_2$	173.01
02-2256	39640-51-2	ETHYL 6-METHYL-2-PYRIDINECARBOXYLATE, 97%	$C_9H_{11}NO_2$	165.19
03-1919	592-51-8	4-PENTENENITRILE, 97%	$CH_2=CHCH_2CH_2CN$	81.12
02-1004	352535-01-4	TETRAKIS(ETHYLMETHYLAMIDO)HAFNIUM (IV), 99.99+%	$[(CH_3)C_2H_5N]_4HF$	410.9
02-1005	175923-04-3	TETRAKIS(ETHYLMETHYLAMIDO)ZIRCONIUM (IV), >=99%, 99.99+% METALS PURITY	$Zr(NCH_3C_2H_5)_4$	323.63
02-2378	598-45-8	ISOPROPYL ISOCYANIDE, 97%	$(CH_3)_2CHNC$	69.11
02-2416	19614-12-1	2-BROMO-5-METHOXYBENZYL BROMIDE, 97%	$BrC_6H_4(CH_2Br)OCH_3$	279.96
02-2097	17906-35-3	TRIS(TERT-PENTOXY)SILANOL 99.99+%	$(CH_3CH_2C(CH_3)_2O)_3SiOH$	306.51
02-1484	18166-43-3	TRIS(T-BUTOXY)SILANOL 99.999%	$((CH_3)_3CO)_3SiOH$	264.43
03-1619	3622-23-9	2,6-DICHLOROBENZOTHAZOLE, 97%	$C_7H_3Cl_2NS$	204.08
03-1349	13534-99-1	2-AMINO-3-BROMOPYRIDINE, 97%	$C_5H_5BrN_2$	173.01
03-2319	64744-50-9	4,4-PENTAMETHYLENE-2-PYRROLIDINONE, 96%	$C_9H_{15}NO$	153.22
03-1447	52200-48-3	3-BROMO-2-CHLOROPYRIDINE, 98%	C_5H_3BrClN	192.44
02-1023	1122-28-7	4,5-DICYANOIMIDAZOLE, 99.0%	$C_3H_2N_4$	118.1
03-1399	33674-96-3	(6-BROMO-PYRIDIN-2-YL)METHANOL, 96%	C_6H_6BrNO	188.02
03-2316	15088-78-5	PHENYLACETYL DISULFIDE, 96%	$(C_6H_5CH_2COS)_2$	302.41
02-2495	6547-53-1	(4-BENZYLOXY)PHENYLACETIC ACID, 98%	$C_6H_5CH_2OC_6H_4CH_2CO_2H$	242.27
02-1340	1877-71-0	MONO-METHYL ISOPHTHALATE, 97%	$C_6H_4(CO_2H)CO_2CH_3$	180.16
02-1743	4470-83-1	2,8-DICHLOROQUINOLINE, 96%	$C_8H_5Cl_2N$	198.05
02-1313	73842-99-6	3-((TERT-BUTYLDIMETHYLSILYL)OXY)PROPANOL, 97%	$(CH_3)_3CSi(CH_3)_2OCH_2CH_2CH_2OH$	190.36
02-1177	123855-51-6	N-BOC-4-PIPERIDINEMETHANOL, 97%	$C_{11}H_{21}NO_3$	215.29
03-2033	69360-26-5	2-CYANOBENZENESULFONYL CHLORIDE, 98%	$NCC_6H_4SO_2Cl$	201.63
02-2182	2459-07-6	METHYL PICOLINATE, 99%	$C_7H_9NO_2$	137.14
03-2261	81778-09-8	2-CHLORO-5-FLUOROBENZYL BROMIDE, 99%	$ClC_6H_3(F)CH_2Br$	223.47
02-1650	705-31-7	4-ETHYNYL-ALPHA,ALPHA,ALPHA-TRIFLUOROTOLUENE, 97%	$HC\equiv CC_6H_4CF_3$	170.13
02-1414	302912-34-1	1-ETHYNYL-2,4-DIFLUOROBENZENE, 97%	$HC\equiv CC_6H_3F_2$	138.11
03-1946	25233-30-1	POLYANILINE, EMERALDINE BASE, MW CA. 5,000		
02-2598	4441-56-9	CYCLOHEXYL BORONIC ACID	$C_6H_{13}BO_2$	127.98
03-1162	32477-35-3	N-HEPTAFLUOROBUTYRYLIMIDAZOLE, 97%	$C_7H_5F_7N_2O$	264.1
03-1360	123847-85-8	N,N'-DI-((1-NAPHTHYL)-N,N'-DIPHENYL)-(1,1'-BIPHENYL)-4,4'-DIAMINE, 99%, SUBL.	$C_{44}H_{32}N_2$	588.74
02-1891	175845-21-3	2,8,9-TRISOPROPYL-2,5,8,9-TETRAAZA-1-PHOSPHABICYCLO(3.3.3)UNDECANE	$PN(CH(CH_3)_2)_2CH_2CH_2NCH_2CH_2N(CH(CH_3)_2)_2$	300.42
03-2136	66176-39-4	4-(BROMOMETHYL)BENZENESULFONYL CHLORIDE, 95%	$BrCH_2C_6H_4SO_2Cl$	269.54

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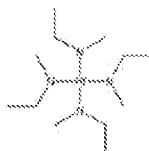
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Product Code	GMHFG83
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HMIS	3-0.1-5 HHS Key
MW	415.86328
BP (°C/mmHg)	78 / 0.01
Specific Gravity	1.524 /
Purity	
Comments	
Additional Properties	
Application	
References	
Notes	

Formula	$C_{12}H_{10}N_4O_4$
EGF	No
MP °C	—
Calculated Index	1
Flash Point	150°C (300°F)

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NANMAT TECHNOLOGY CO.,LTD.



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PRODUCTS

Nanomat has already started to produce products and to develop new technologies in the following categories :

1. Ultra-high purity CVD precursors :

These precursors are widely used in semiconductor industry, including TEOS, TMPT, TMB, TEB, TEPO, TDEAT/TDMAT, TiCl₄, TAETO, TEMAH, TBDEET, DMAH, and many other metals, oxides and nitrides Precursors. The purity of these chemicals can be as high as 8N5 (99.999995% metal purity).

2. NanoMate Solution and MGTEK :

This revolutionary technology can be applied on different metals, such as aluminum, steel, stainless steel, copper, magnesium, titanium, and their alloys, to improve the adhesion of metals with adhesives and paints, and also to improve the corrosion resistance. This process has been proven as a replacement for anodization and acid etching with less cost, higher throughput and no pollution, as to meet the criteria of Non-Chromate's era.

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Praxair® TEMAH High-Purity Hafnium Source

Tetrakis(isoethylamino)hafnium
 $\text{Hf}(\text{C}_2\text{H}_5)_4$

Properties:	TEMAH
Molecular weight	110.93 g/mol
Appearance	Colorless liquid
Melting point	< -20°C
Boiling point	2.65 mmHg (boiling 71)
Vapor pressure	1.0 mmHg at 20°C
Density	2.02 g/mL at 20°C
Viscosity	2.1 cP at 20°C
Thermal stability at 10°C (N ₂)	< 1% decomposition in one year
Grade	99.999% min
Purity	99.999% min

Packaging:
 Packaging for this compound is available in 500 gL, 1000 gL, and 2.0 L and 5.0 L containers.

Vapor Pressure Curve - 0.5 mm at 80°C:

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Purity: 99.99%
Form: 8

1 of 2

Synonym:
 TEMAH

Tetrakis(ethylmethanimido)hafnium(IV)

Molecular Formula:
 $(C_2H_5)_4HfN_4$

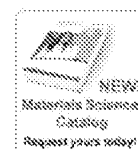
Molecular Weight:
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CAS Number:
 56233-01-4
 MFCC03427130

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PubChem Substance ID:
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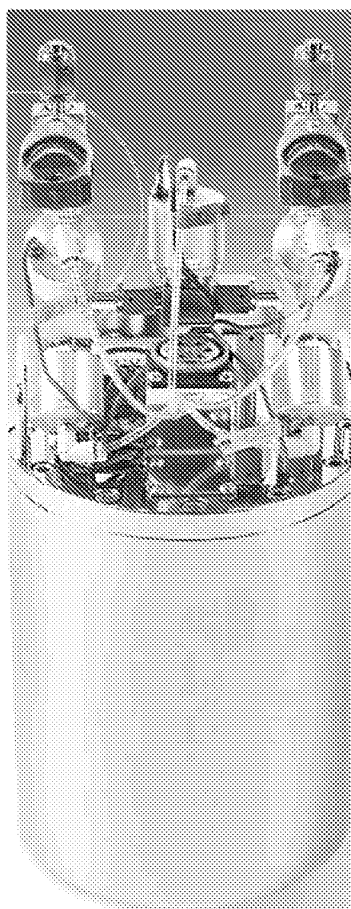
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[Products]

* Metal-Oxide CVD & ALD Precursor

Al₂O₃ - ALD & CVD -> TMA, MPA
 HfO₂ - ALD & CVD -> TEMA, Hf(OiBu)₄
 ZrO₂ - ALD & CVD -> TEMA
 SiO₂ - ALD & CVD -> TEMA, TMDSO
 Hf-SiO₂ - ALD & CVD -> TEMA + TEMA-Mixture
 Ta₂O₅ - ALD & CVD -> TAETONPETI, TATERMAE
 BST/PZT - ALD & CVD -> Coetalk(®), New Ti

* Metal-Nitride CVD & ALD Precursor

TiN - ALD & CVD -> TEMA, TiCl₄, etc.
 TaN - ALD & CVD -> PEMA, TBDET, TBITEMAT, etc.

* Al - CVD & ALD Precursor

MPA, etc.

* Cu - ALD & CVD Process Precursor

* Cu(hfac)₂, Cu(VTMO), Cu(®), Cu(®), etc.

* Au-etchant

* Others

~ 200 R&D chemicals

Co, Ru, W, Mo, Cr - ALD & CVD Precursor, Sources for Diffusion Barrier Layer, etc.
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316L EP polished / Wetted Surface, Minimized splashing design, Easy replaceable design

* Continuous type Sensor

outside mounting, 2 points adjustable alarm set, temperature compensation

* Multi Points Level Sensor



maximum working temperature, 120°C

1/2" FVCR connection

316L EP polished probe, Splash free design probe

Valid Until: 2006/04/19

[Contact Info]

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