Tribute to John W. Coburn

David B. Graves

University of California, Berkeley

NCCAVS

February 22, 2019

San Jose, CA USA

John's Biography

John was born in Vancouver, British Columbia and remained a Canadian citizen all his life.

He received a Bachelor's degree in Engineering Physics from the University of British Columbia and a PhD in Electrical Engineering from the University of Minnesota.

John met his wife Sharon in Minneapolis in 1964 and they married in 1966. They had 2 children: David and Stephen.

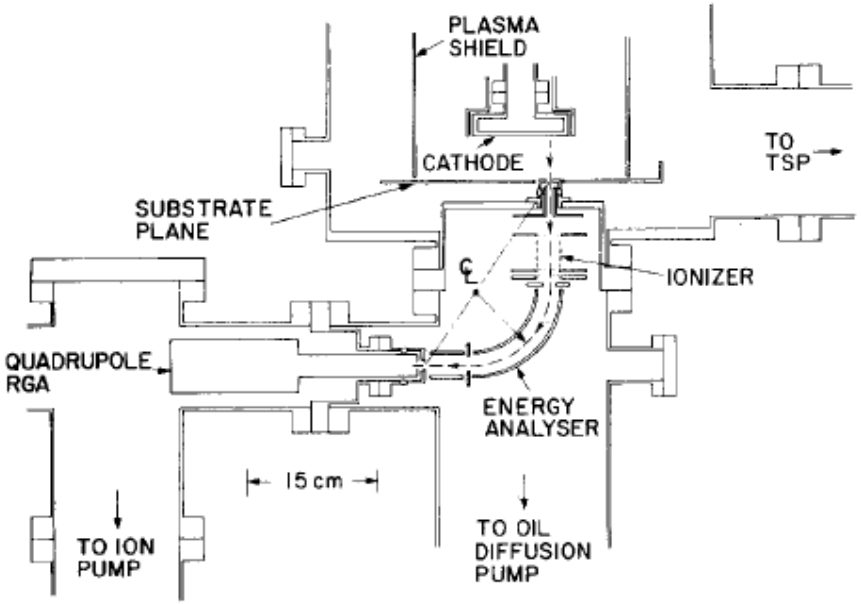
After his postdoctoral work at Simon Fraser University, John joined IBM Research (Almaden) in 1978. John worked at IBM for 25 years, and retired in 1993.

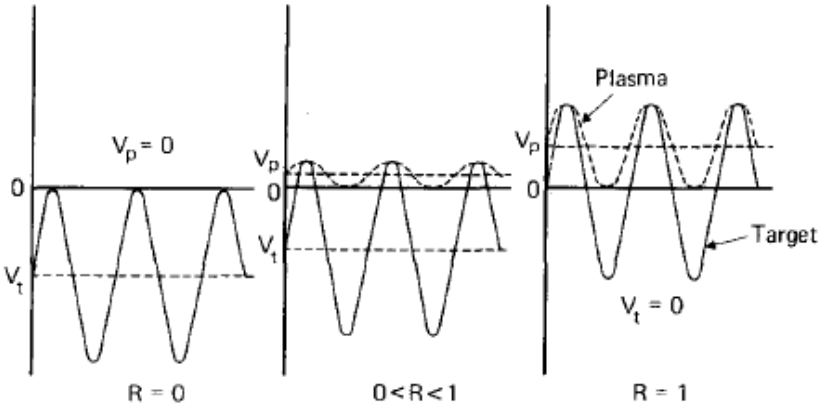
He joined me at UC Berkeley in 1994 after a year in Germany and we worked together for over 20 years.

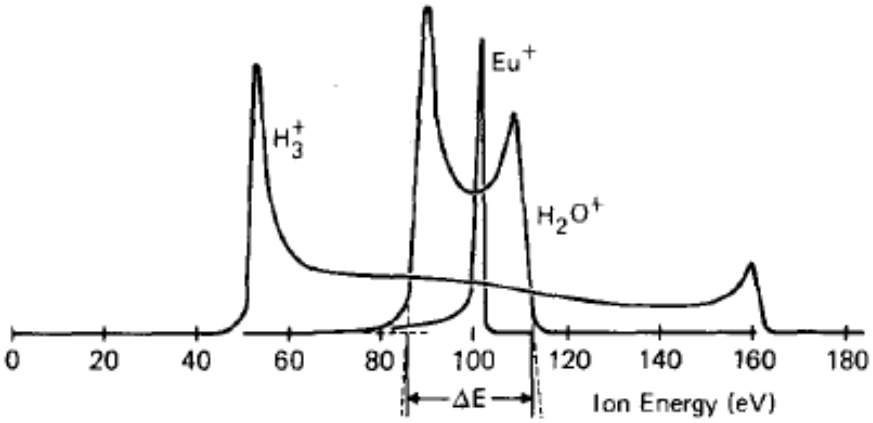
J. Appl. Phys., Vol. 43, No. 12, December 1972

Positive-ion bombardment of substrates in rf diode glow discharge sputtering

J. W. Coburn and Eric Kay
IBM Research Laboratory, San Jose, California 95114
(Received 3 July 1972; in final form 28 August 1972)







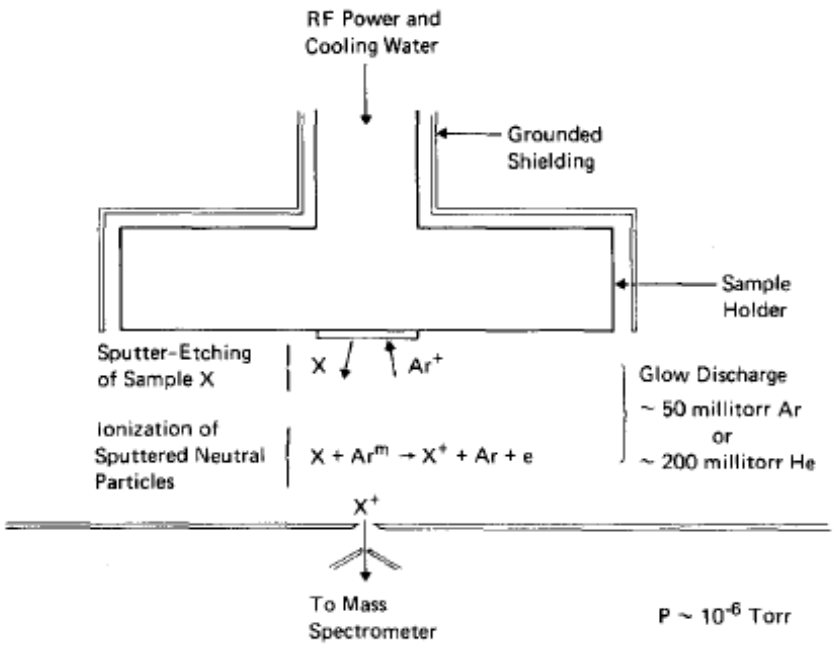
Measuring ion energies at surfaces with role of plasma potential

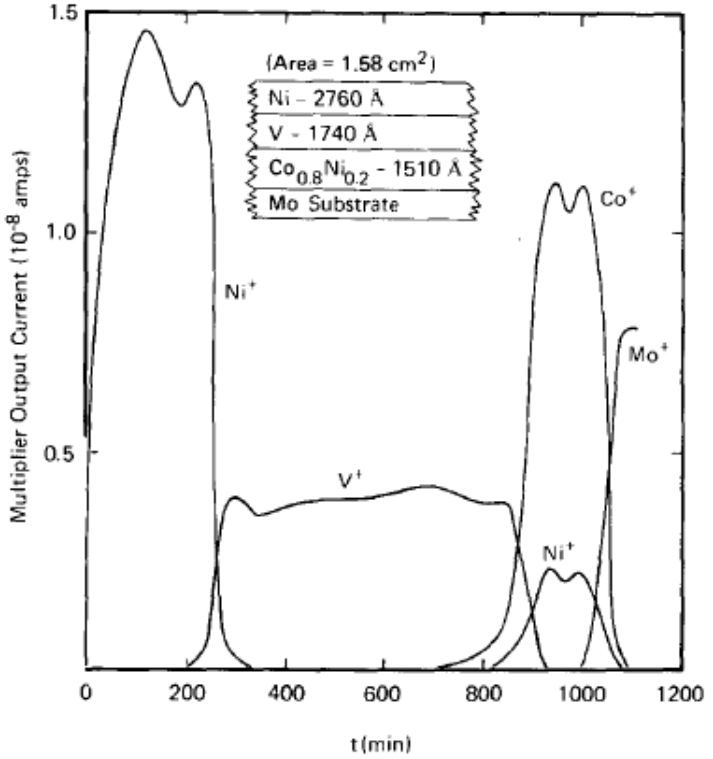
1779 Journal of Applied Physics, Vol. 45, No. 4, April 1974

Glow-discharge mass spectrometry—Technique for determining elemental composition profiles in solids

J. W. Coburn, E. Taglauer*, and Eric Kay

IBM Research Laboratory, San Jose, California 95193
(Received 21 September 1973)





Ion sputtering and detection of composition in gas phase

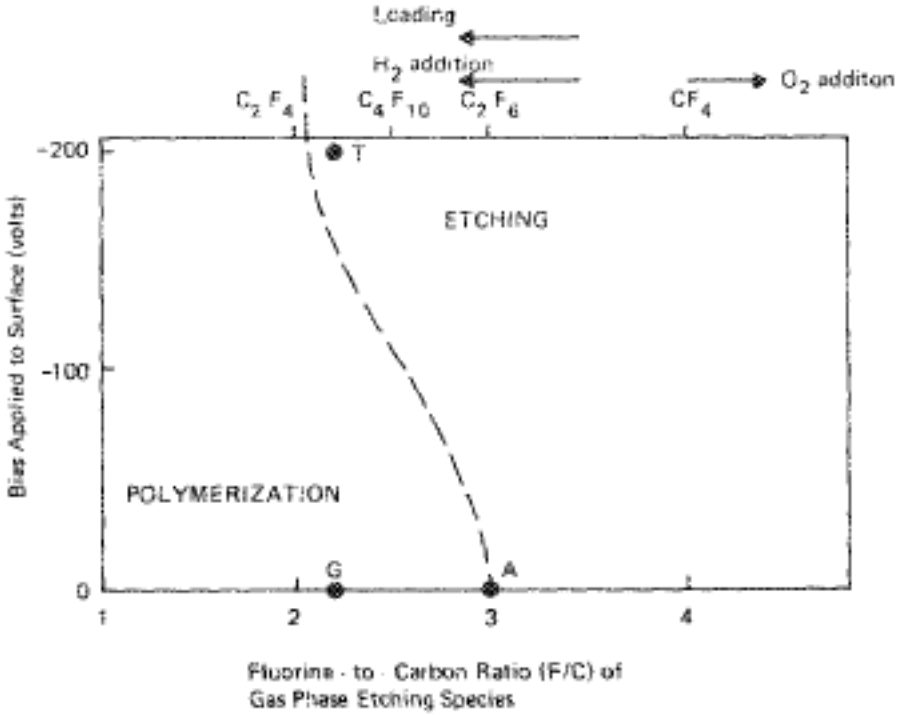
Plasma etching—A discussion of mechanisms

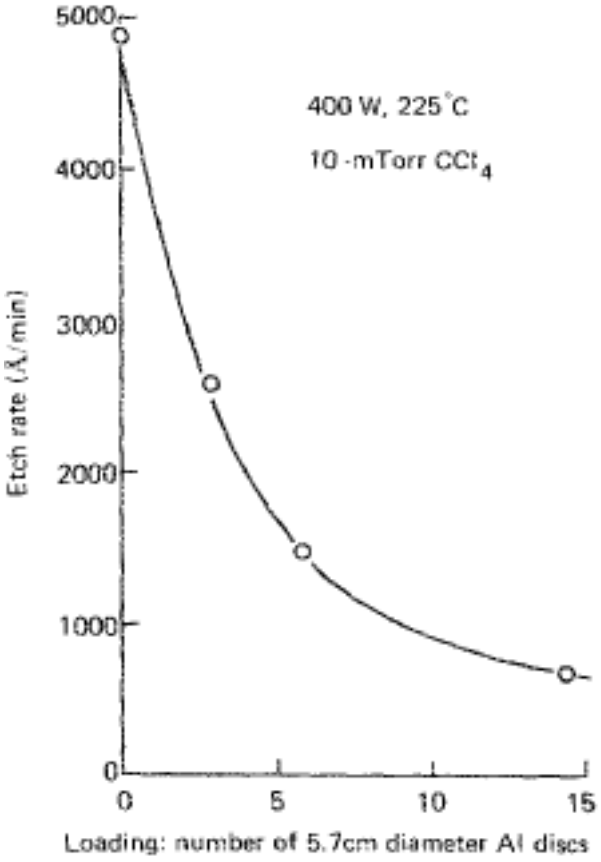
J. W. Coburn and Harold F. Winters

IBM Research Laboratory, San Jose, California 95193

(Received 7 October 1978; accepted 18 January 1979)

Fluorine-to-carbon ratio concept





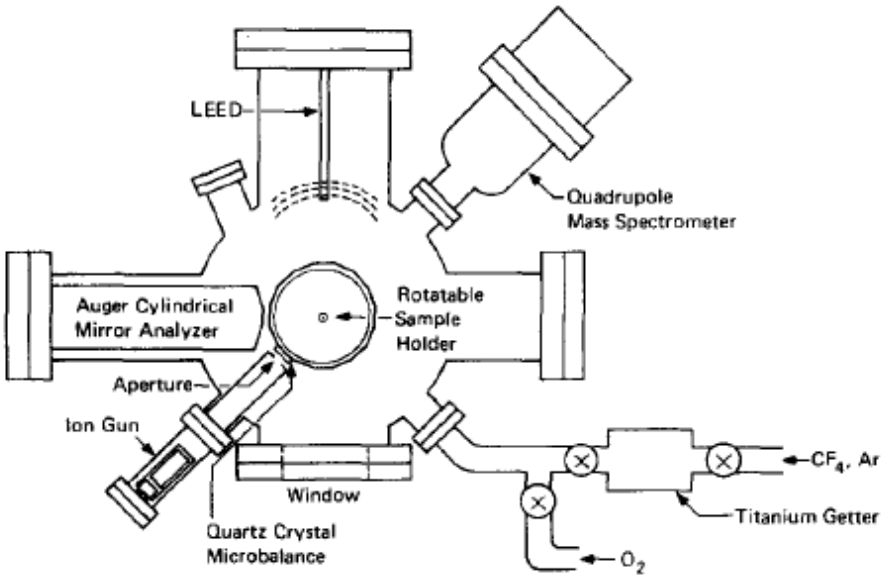
B. Active species consumption by etching—the loading effect

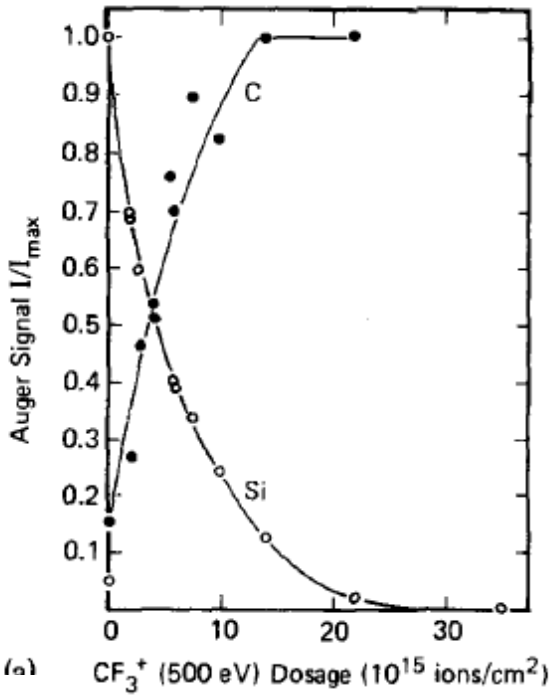
Key chemical concepts in plasma etch

Ion-surface interactions in plasma etching

J. W. Coburn, H. F. Winters, and T. J. Chuang

IBM Research Laboratory, San Jose, California 95193
(Received 21 February 1977; accepted for publication 12 April 1977)





It is suspected that the deposition and removal of carbon is one of the most important phenomena affecting the operating characteristics of plasma-etching systems.

Ions and surfaces in plasma etch

70 Appl. Phys. Lett. 34(1), 1 January 1979

The etching of silicon with XeF_2 vapor

H. F. Winters and J. W. Coburn

IBM Research Laboratory, San Jose, California 95193
(Received 1 September 1978; accepted for publication 9 October 1978)

(1) The etching reaction produced by fluorine atoms often can be simulated by using a flux of XeF_2 as a source of fluorine.

(2) XeF_2 isotropically etches silicon with the etch rate being limited by the incident flux. Etch rates greater than a μm/min can be easily achieved with unsophisticated hardware and a simple vacuum system.

(3) Pattern delineation using thin masks of SiC, SiO_2, or Si_3N_4 is attractive since XeF_2 attacks silicon but not these compounds, but etching is isotropic, so very fine patterns cannot be delineated.

Fundamentals of surface chemistry in plasma etch

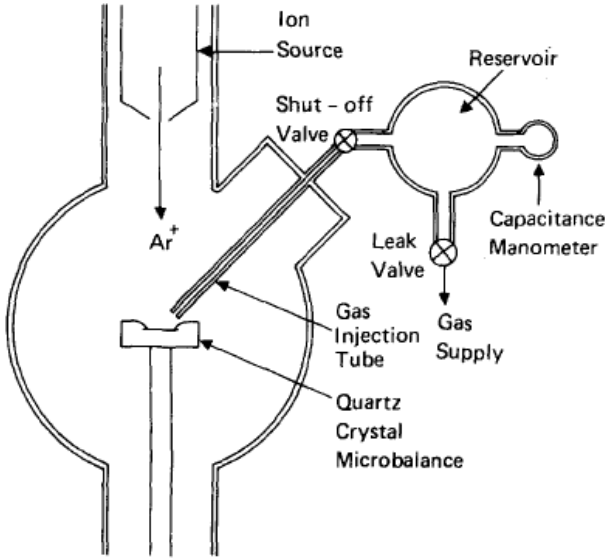
3189 J. Appl. Phys. 50(5), May 1979

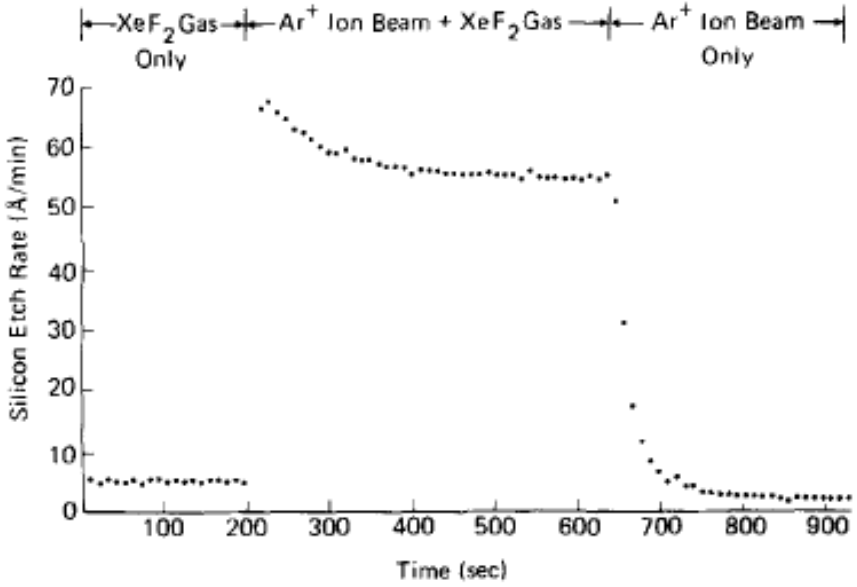
Ion- and electron-assisted gas-surface chemistry—An important effect in plasma etching

J. W. Coburn and Harold F. Winters

IBM Research Laboratory, San Jose, California 95193

(Received 23 October 1978; accepted for publication 13 November 1978)





The classic experiment: ion-neutral synergism in plasma etch

Optical emission spectroscopy of reactive plasmas: A method for correlating emission intensities to reactive particle density

J. W. Coburn and M. Chen
IBM Research Laboratory San Jose, California 95193

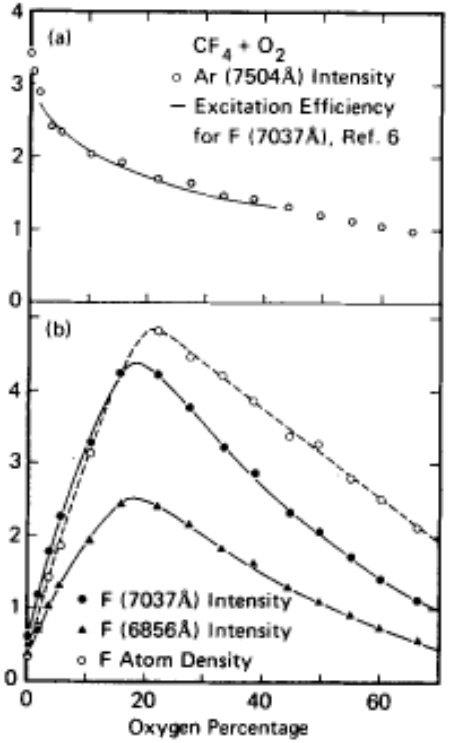
(Received 7 December 1979; accepted for publication 13 February 1980)

The addition of a small concentration of suitably chosen noble gas to a reactive plasma is shown to permit the determination of the functional dependence of reactive particle density on plasma parameters. Examples illustrating the simplicity of this method are presented using F atomic emission from plasma-etching discharges and a comparison is made to available data in the literature.

$$n_F/n_{Ar} = K\, I_F/I_{Ar},$$

$$I_F = k_F n_F \eta_F,$$

$$I_{Ar} = k_{Ar} n_{Ar} \eta_{Ar}$$



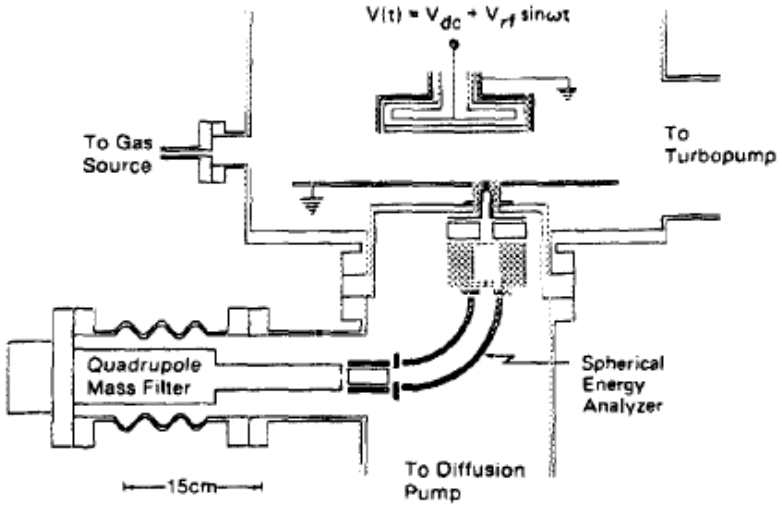
Actinometry – a simple but extremely useful idea to exploit OES in plasmas

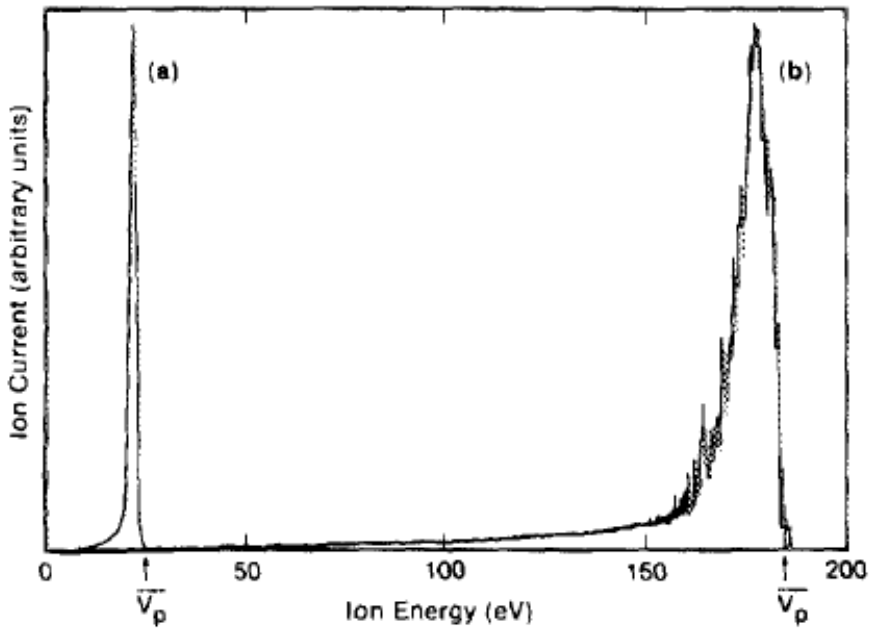
Plasma potentials of 13.56-MHz rf argon glow discharges in a planar system

K. Köhler,[a] J. W. Coburn, D. E. Horne, and E. Kay
IBM Research Laboratory, San Jose, California 95193

J. H. Keller
IBM General Technology Division, Hopewell Junction, New York 12533

(Received 30 January 1984; accepted for publication 26 June 1984)



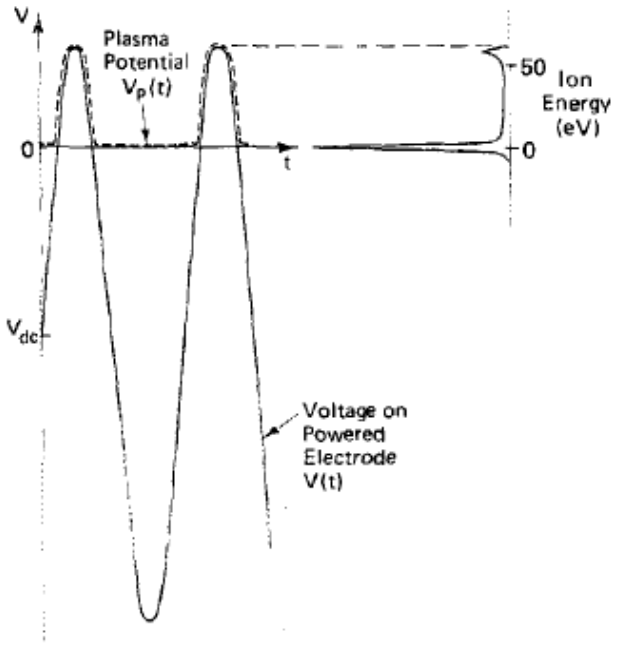


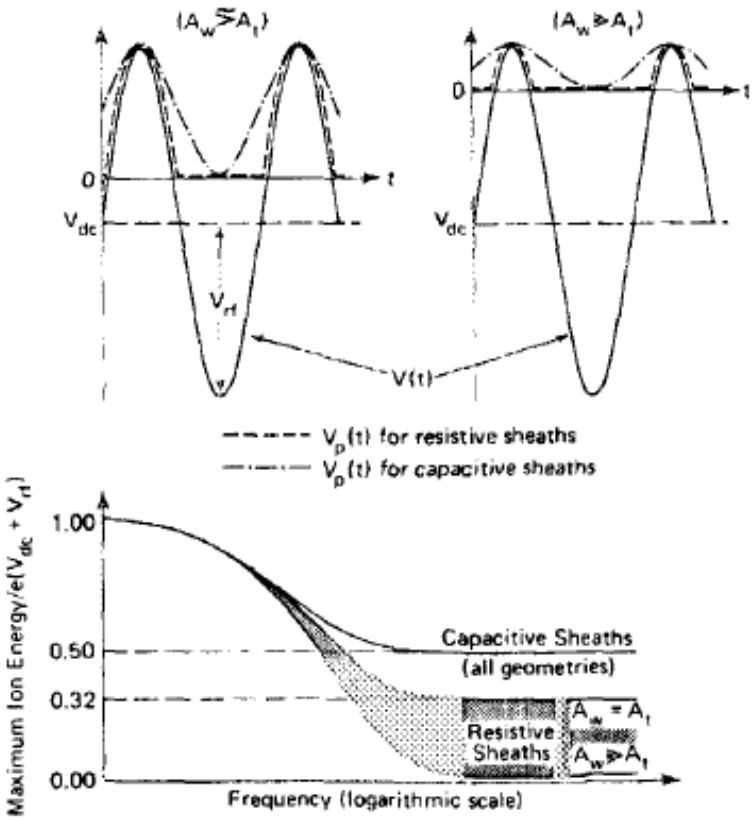
Coupling ion energy measurements with understanding plasma electrical behavior

Frequency dependence of ion bombardment of grounded surfaces in rf argon glow discharges in a planar system

K. Köhler,[a] D. E. Horne, and J. W. Coburn
IBM Research Laboratory, San Jose, California 95193

(Received 24 June 1985; accepted for publication 17]





Approximate models of RF discharge physics

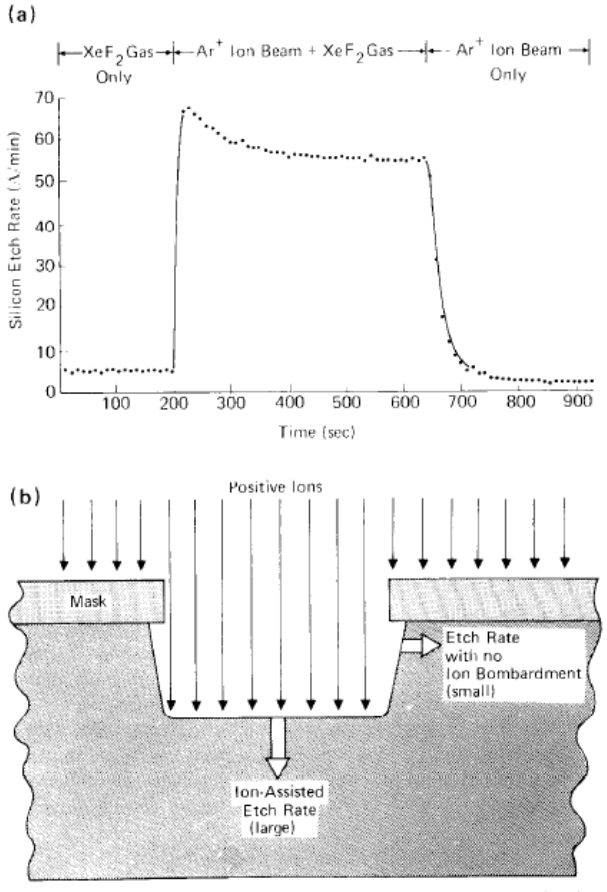
Surface Science Reports 14 (1992) 161–269

Surface science aspects of etching reactions

Harold F. Winters and J.W. Coburn

IBM Research Division, Almaden Research Center, 650 Harry Road, San Jose, CA 95120-6099, USA

Manuscript received in final form 22 October 1991



The magnum opus on plasma-surface interactions in etching….

Some of John's Student Collaborations at UC Berkeley

1. Molecular dynamics studies with Maria Barone, Dave Humbird, Bryan Helmer, Cam Abrams, and Joe Vegh

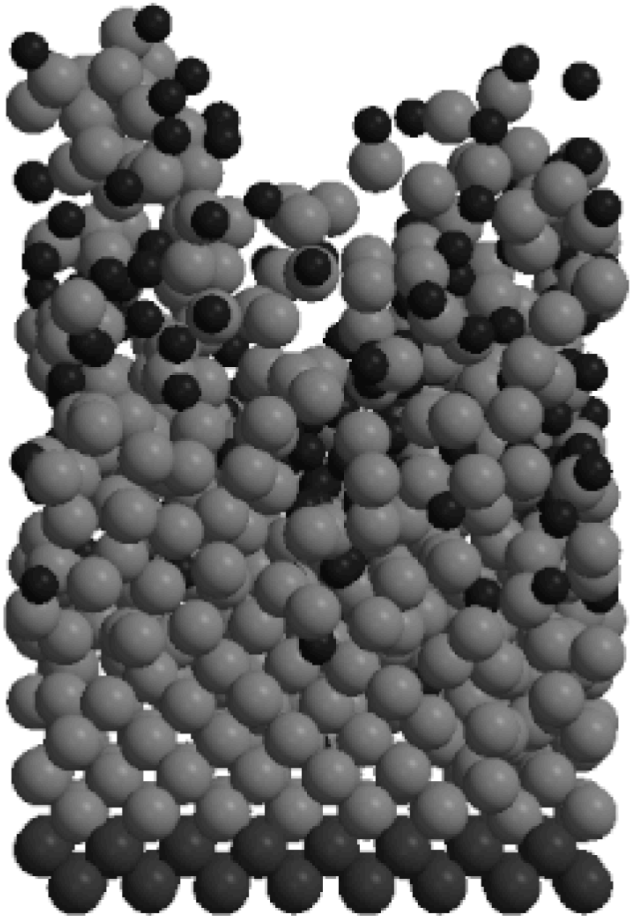
2. Beam studies with Gowri Kota, Frank Greer and Kasi Kiehlbaugh

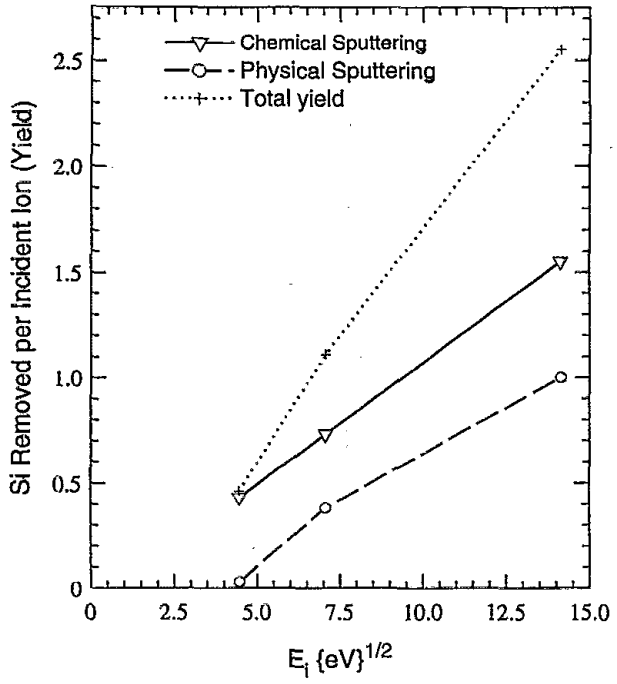
3. ICP plasma studies with Harmeet Singh, Matt Radke, Jerry Hsu, Monica Titus, and Joe Lee

4. Second beam system studies with Yoshie Kimura, Dustin Nest, and Ting-Ying Chung

Maria (Barone) Gray

Pioneering application of molecular dynamics simulations to visualize and understand plasma-surface interactions

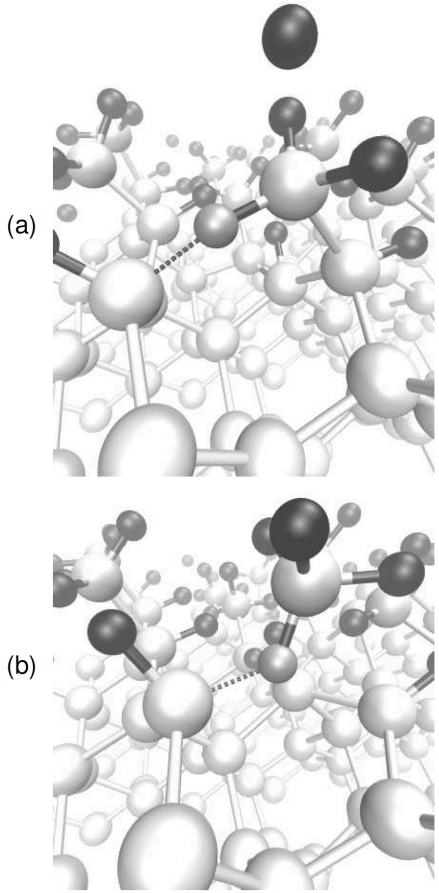


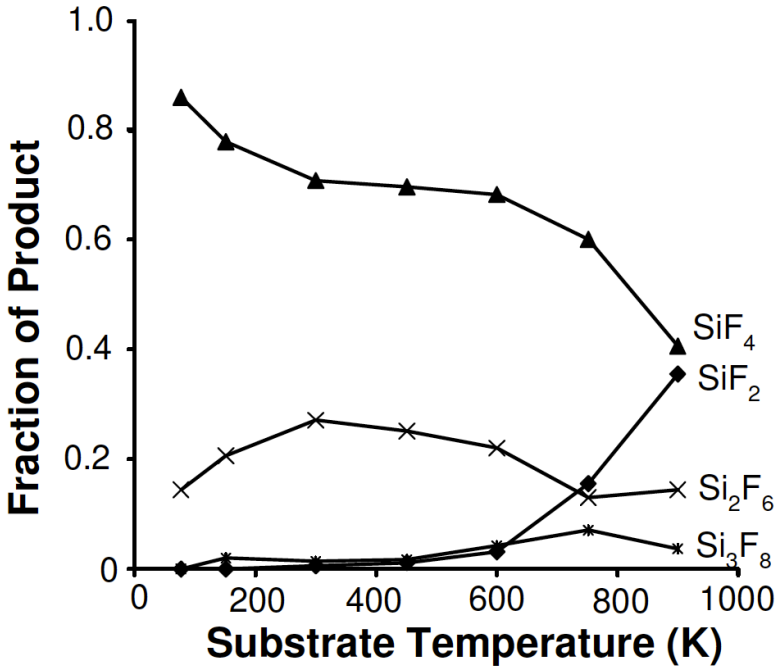


Motivated by original classic experiments of John Coburn and Harold Winters at IBM Research!

David Humbird

Using MD to identify key plasma-etch mechanisms: closely studying published experiments.





Thanks to Harold Winters and John Coburn for many discussions and original experiments!

JOURNAL OF APPLIED PHYSICS VOLUME 96, NUMBER 1 1 JULY 2004

Atomistic simulations of spontaneous etching of silicon by fluorine and chlorine

David Humbird and David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 9 February 2004; accepted 2 April 2004)

JOURNAL OF APPLIED PHYSICS VOLUME 96, NUMBER 5 1 SEPTEMBER 2004

Mechanism of silicon etching in the presence of CF_2, F, and Ar^+

David Humbird and David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 15 March 2004; accepted 18 May 2004)

Atomistic simulations of Ar^+-ion-assisted etching of silicon by fluorine and chlorine

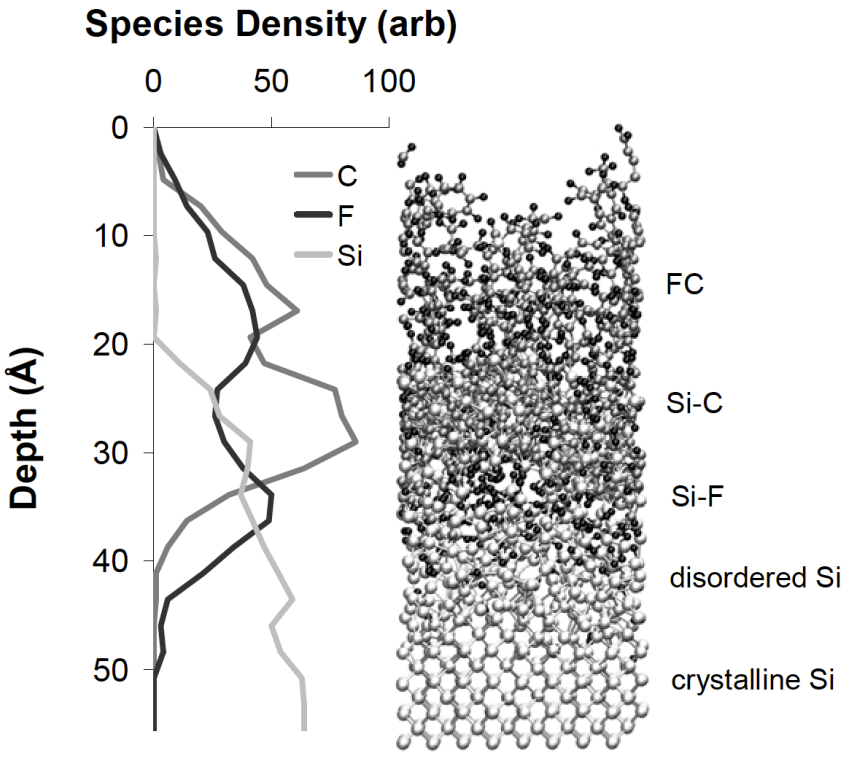
David Humbird
Lam Research, 4650 Cushing Parkway, Fremont, California 94538

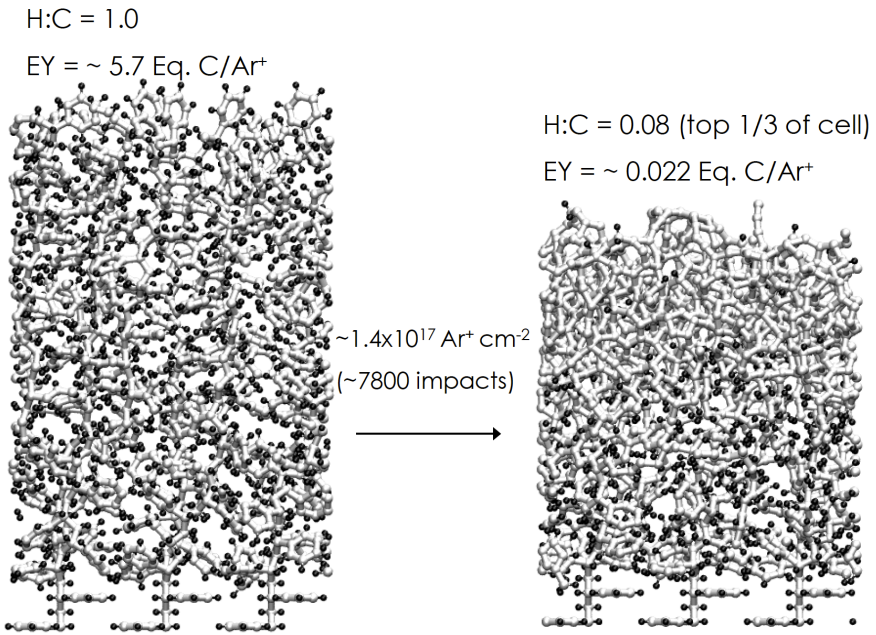
David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 11 March 2004; accepted 13 September 2004; published 24 November 2004)

Joe Vegh

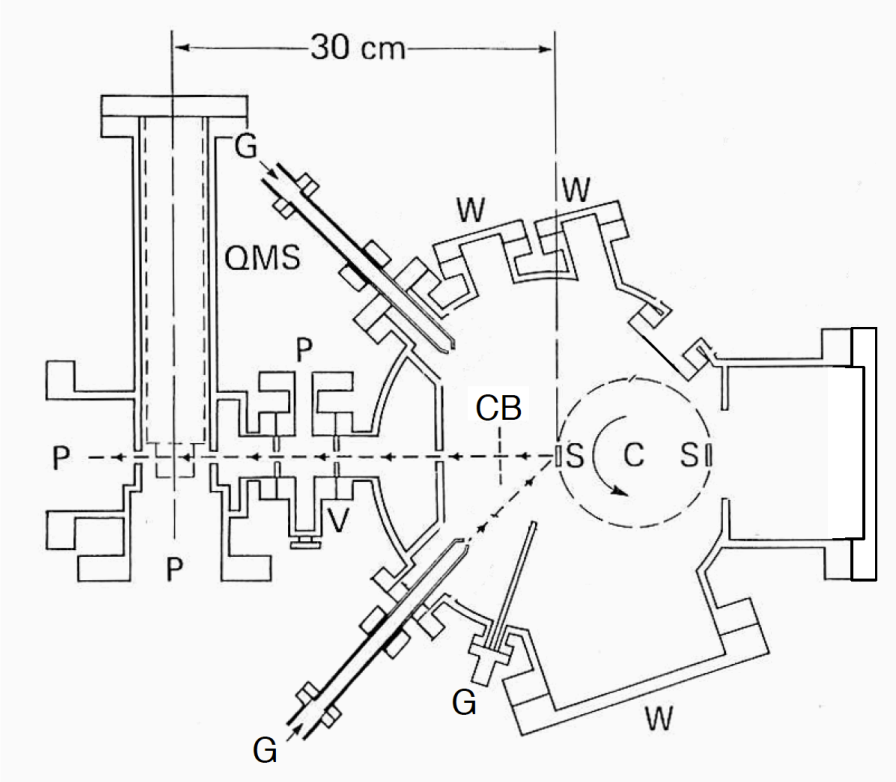
MD simulations of key plasma-surface interactions: FC films during etch and and photoresist roughening.

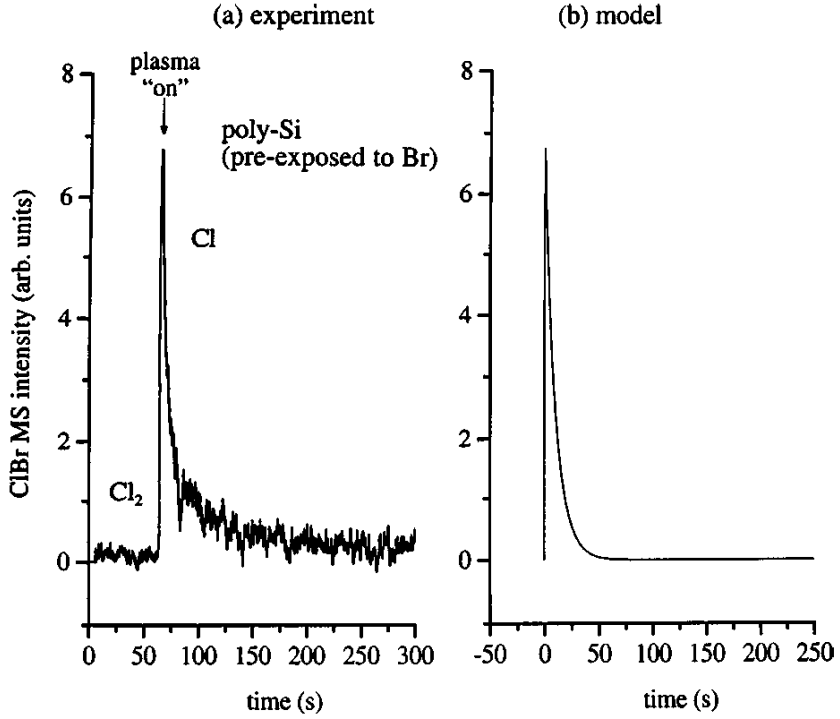




Gowri (Kota) Kamarthy

Using vacuum beam apparatus for first measurements/model of plasma radical - wall abstraction/recombination chemistry.





Apparatus originally built by John Coburn and donated by IBM Research!

JOURNAL OF APPLIED PHYSICS VOLUME 85, NUMBER 1 1 JANUARY 1999

Heteronuclear and homonuclear surface abstraction reactions of Cl, Br, and F

Gowri P. Kota, J. W. Coburn, and David B. Graves
Department of Chemical Engineering, University of California, Berkeley, California 94720

Heterogeneous recombination of atomic bromine and fluorine

Gowri P. Kota, J. W. Coburn, and David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 19 January 1998; accepted 23 October 1998)

Role of oxygen in ion-enhanced etching of poly-Si and WSi_x with chlorine

Gowri P. Kota, J. W. Coburn, and David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 17 December 1997; accepted 10 April 1998)

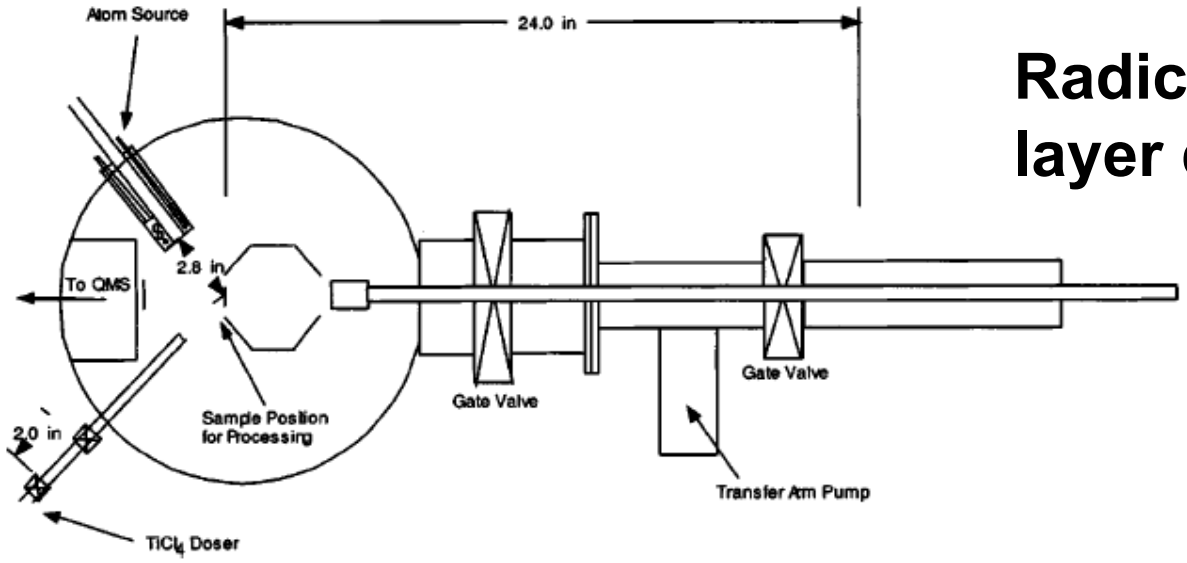
Fundamental beam studies of radical enhanced atomic layer deposition of TiN

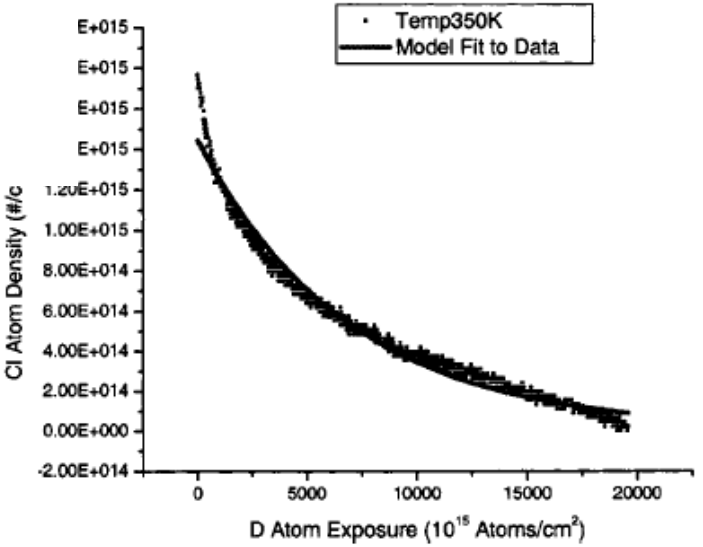
Frank Greer, D. Fraser, J. W. Coburn, and David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 7 May 2002; accepted 30 September 2002; published 2 December 2002)

Frank Greer

Radical-enhanced atomic layer deposition





$TiCl_4$ + D + N beams –> TiN films

Fluorine atom subsurface diffusion and reaction in photoresist

Frank Greer
Novellus Systems, 4000 N. First Street, San Jose, California 95134

D. Fraser, J. W. Coburn, and David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 21 April 2003; accepted 23 September 2003)

Fundamental beam studies of deuterium and fluorine radical reaction kinetics on surfaces

Frank Greer,[a)] D. Fraser, J. W. Coburn, and David B. Graves[b)]
Department of Chemical Engineering, University of California, Berkeley, Berkeley, California 94720

(Received 15 May 2002; accepted 28 April 2003; published 3 July 2003)

Argon and oxygen ion chemistry effects in photoresist etching

Frank Greer, L. Van, D. Fraser, J. W. Coburn, and David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, Berkeley, California 94720

(Received 7 May 2002; accepted 24 June 2002)

Deuterium and fluorine radical reaction kinetics on photoresist*

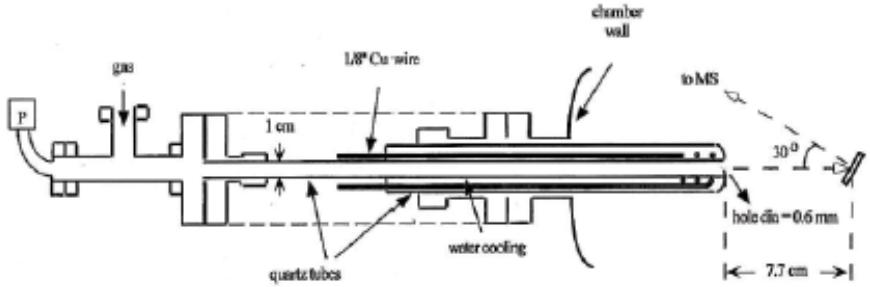
Frank Greer, J. W. Coburn, and David B. Graves[a)]
Department of Chemical Engineering, University of California, Berkeley, California 94720

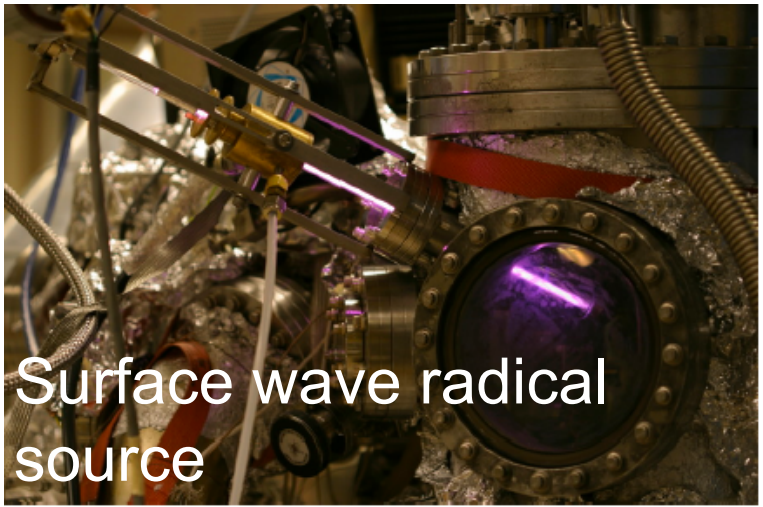
(Received 14 June 2001; accepted 29 October 2001)

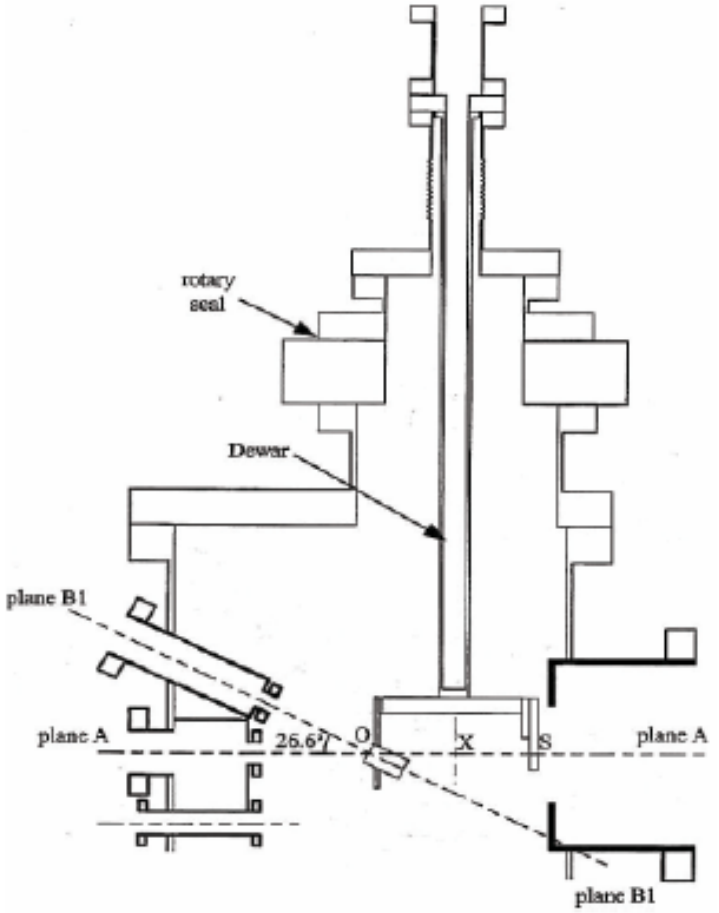
Kasi Kiehlbaugh

Using vacuum beam apparatus with novel radical beam sources.

RF radical source

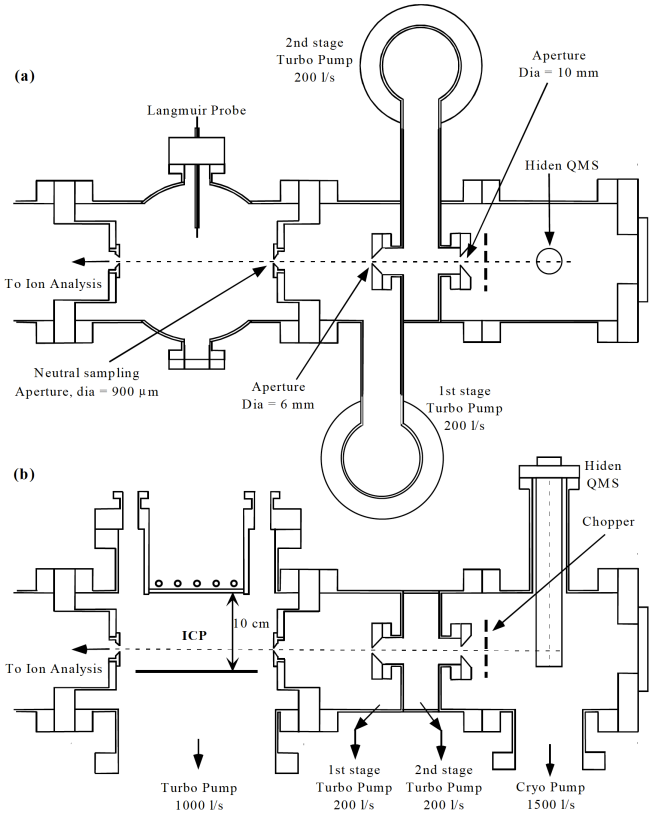


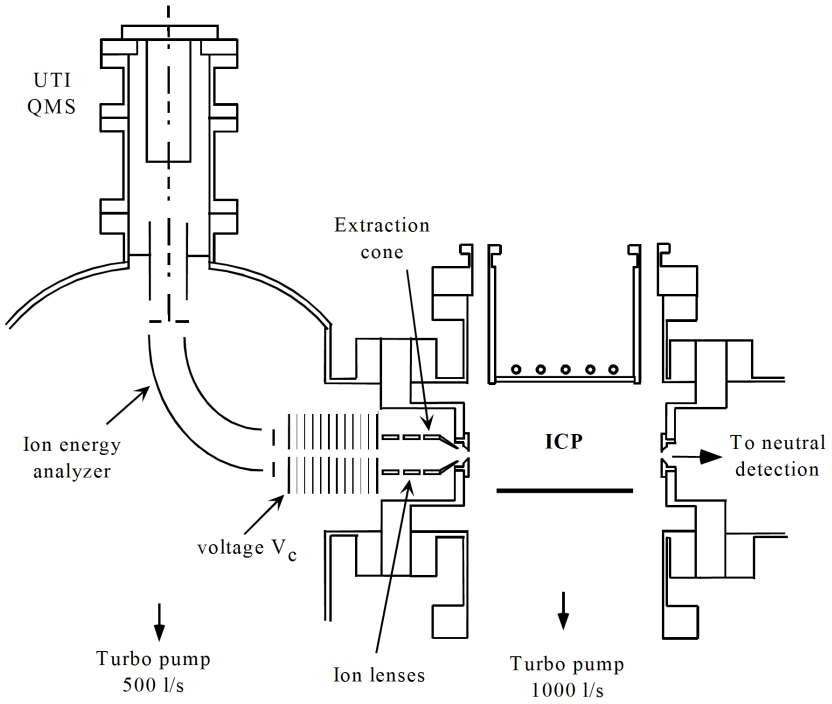




Harmeet Singh

Quantitative radical/ion mass spectrometry and EEDF measurements in ICP





Thanks to John Coburn for design

Measurements of neutral and ion composition, neutral temperature, and electron energy distribution function in a CF_4 inductively coupled plasma

Harmeet Singh,[a] J. W. Coburn, and David B. Graves[b]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 31 May 2000; accepted 15 January 2001)

Surface loss coefficients of CF_x and F radicals on stainless steel

Harmeet Singh, J. W. Coburn, and David B. Graves[a]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 3 February 2000; accepted 17 July 2000)

JOURNAL OF APPLIED PHYSICS VOLUME 88, NUMBER 7 1 OCTOBER 2000

Measurements of the electron energy distribution function in molecular gases in a shielded inductively coupled plasma

Harmeet Singh and David B. Graves[a]
Department of Chemical Engineering, University of California, Berkeley, California 94720

(Received 8 May 2000; accepted for publication 3 July 2000)

Appearance potential mass spectrometry: Discrimination of dissociative ionization products

Harmeet Singh, J. W. Coburn, and David B. Graves[a]
Department of Chemical Engineering, University of California, Berkeley, California 94720

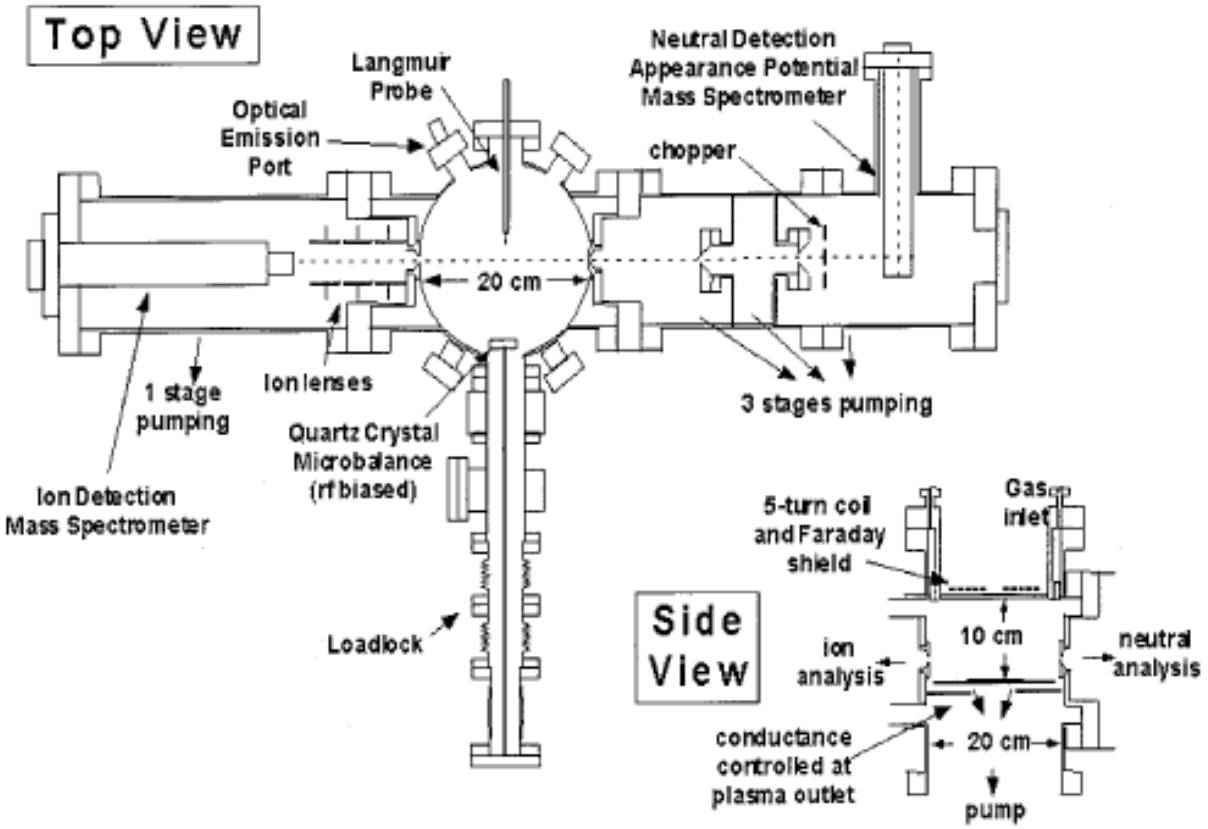
(Received 8 October 1999; accepted 17 December 1999)

C_4F_8 dissociation in an inductively coupled plasma

M. T. Radtke,[a] J. W. Coburn, and David B. Graves
Department of Chemical Engineering, University of California, Berkeley, California

(Received 11 July 2002; accepted 21 April 2003; published 13 June 2003)

Matt Radke



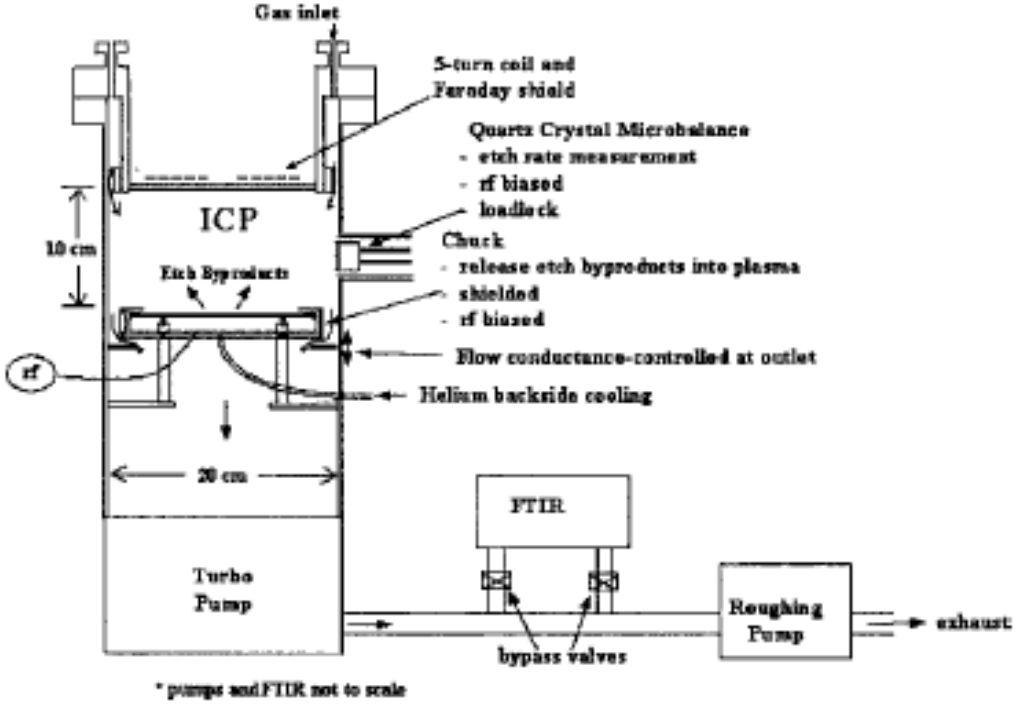
1 J. Vac. Sci. Technol. A 24(1), Jan/Feb 2006

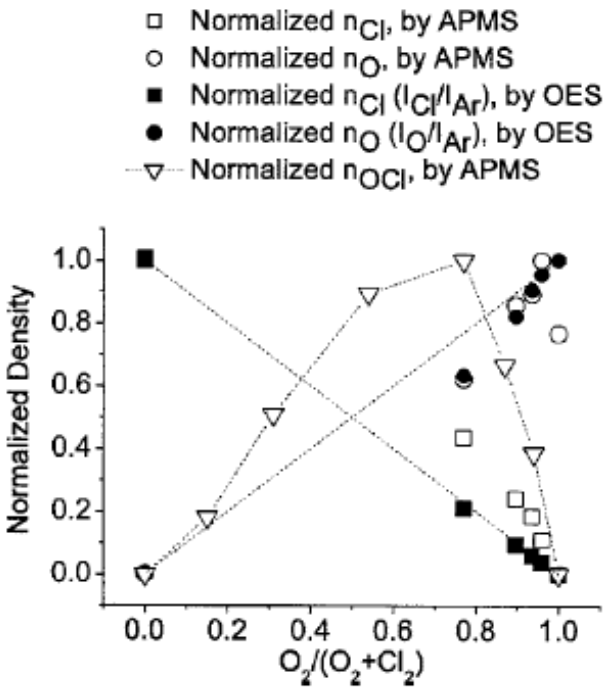
Etching of ruthenium coatings in O_2- and Cl_2-containing plasmas

C. C. Hsu, J. W. Coburn, and D. B. Graves[a)]
Department of Chemical Engineering, University of California at Berkeley, Berkeley, California 94720

(Received 3 March 2005; accepted 20 September 2005; published 9 December 2005)

Cheng-Che (Jerry) Hsu



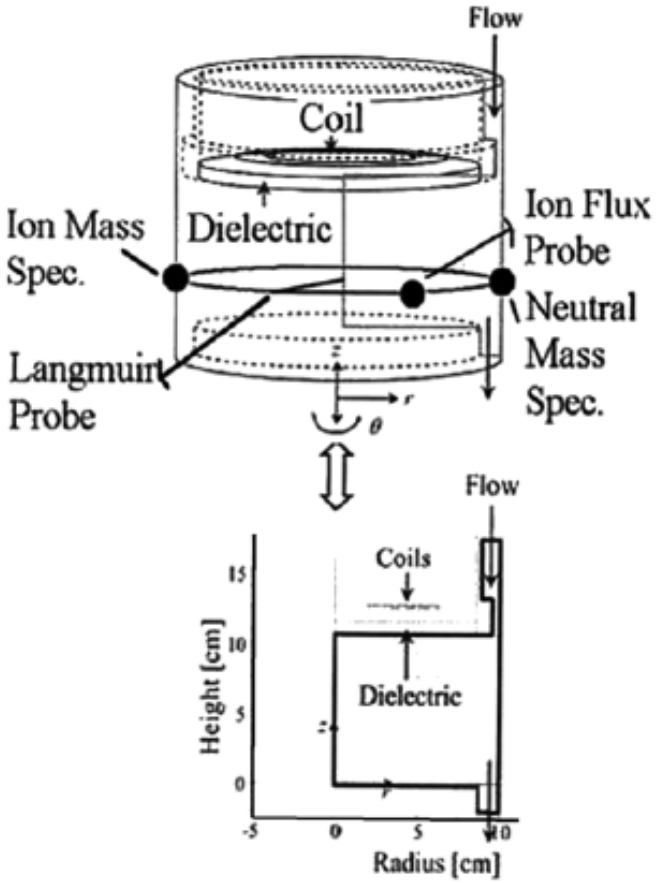


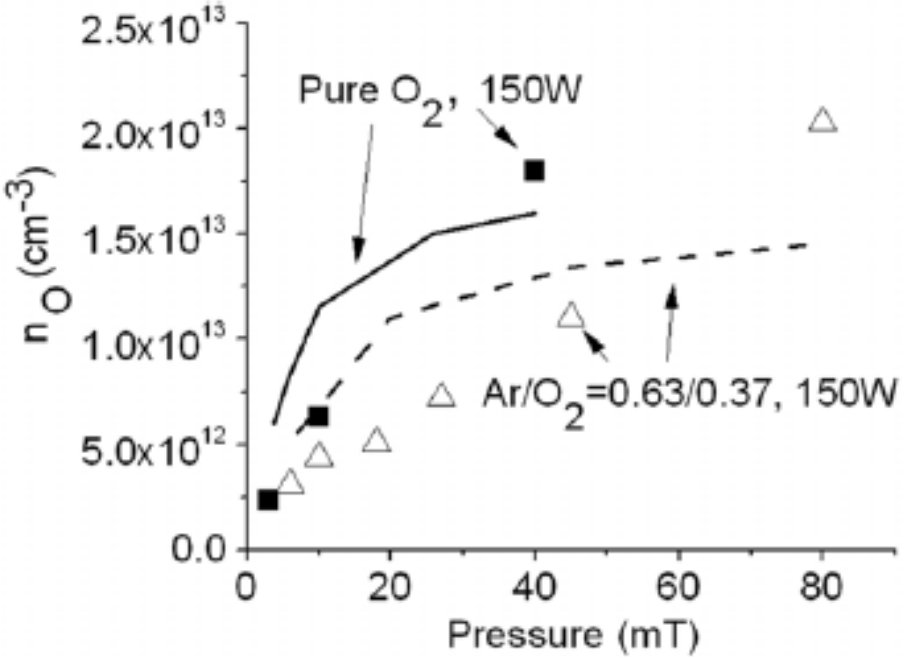
J. Phys. D: Appl. Phys. **39** (2006) 3272–3284 doi:10.1088/0022-3727/39/15/009

Comparison of model and experiment for Ar, Ar/O_2 and $Ar/O_2/Cl_2$ inductively coupled plasmas

Cheng-Che Hsu[1], Mark A Nierode[1,2], John W Coburn[1] and David B Graves[1,3]

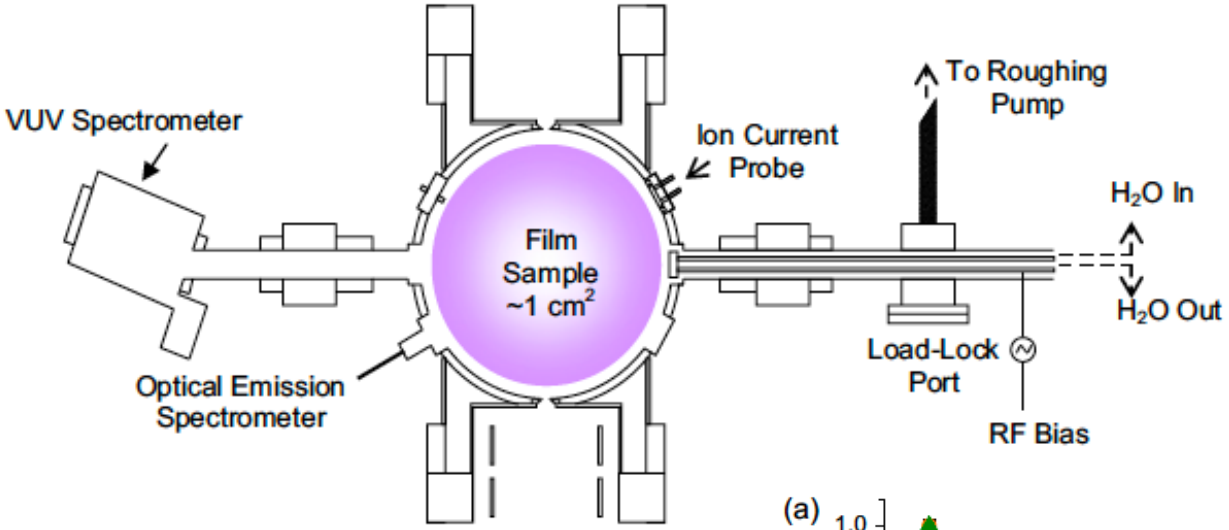
Mark Nierode

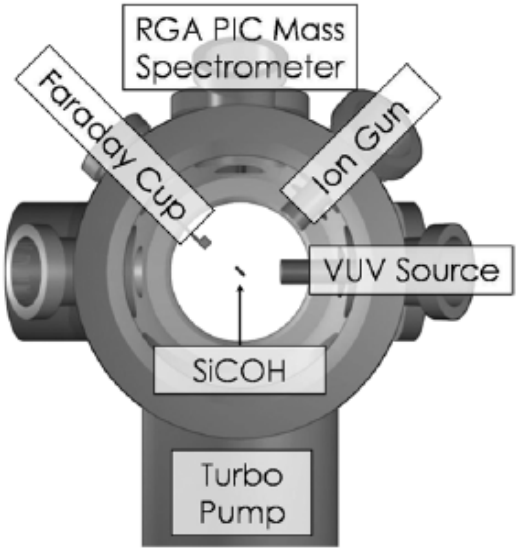


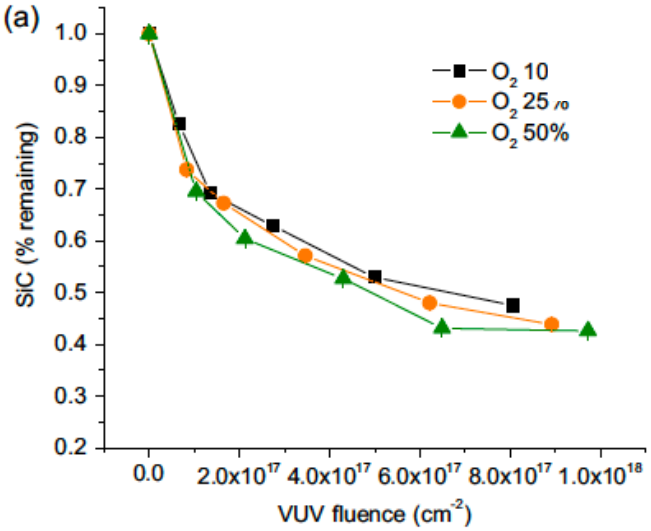


Joe Lee

Fundamental studies of porous low dielectric damage in plasmas







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Vacuum beam studies of fluorocarbon radicals and argon ions on Si and SiO_2 surfaces*

Yoshi Kimura

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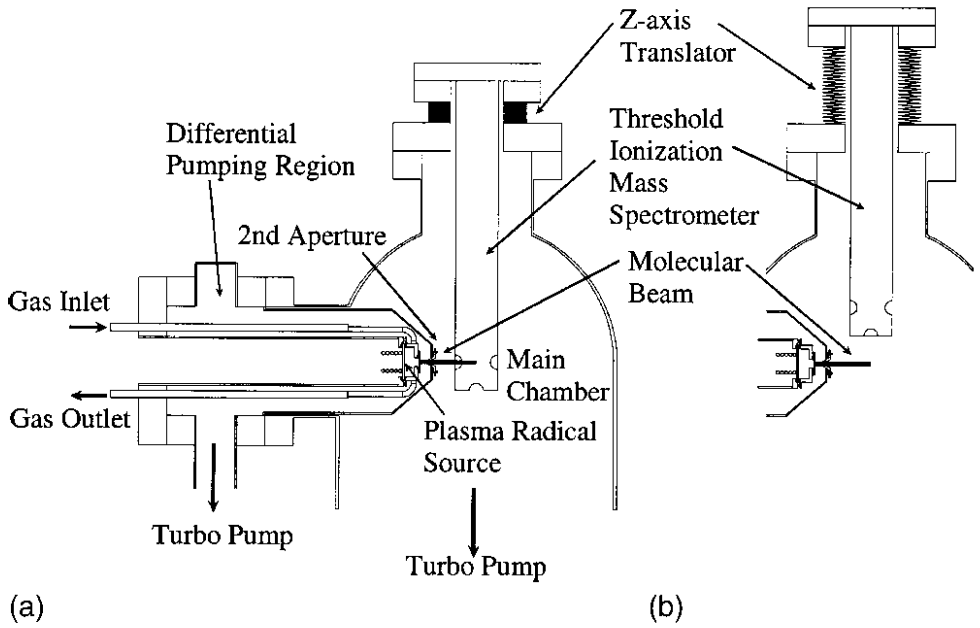
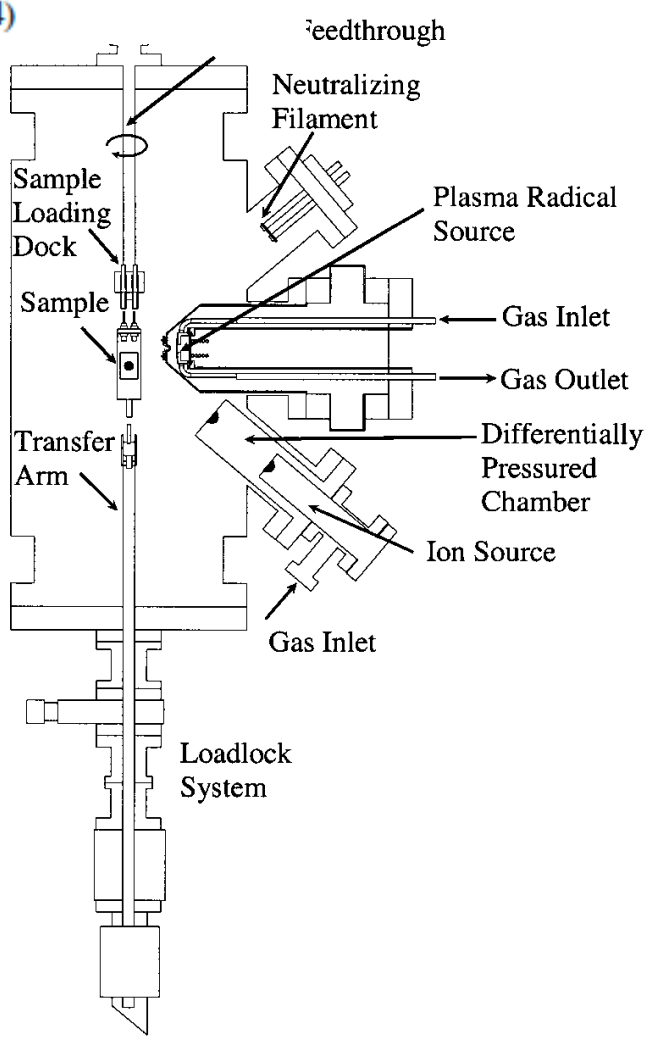
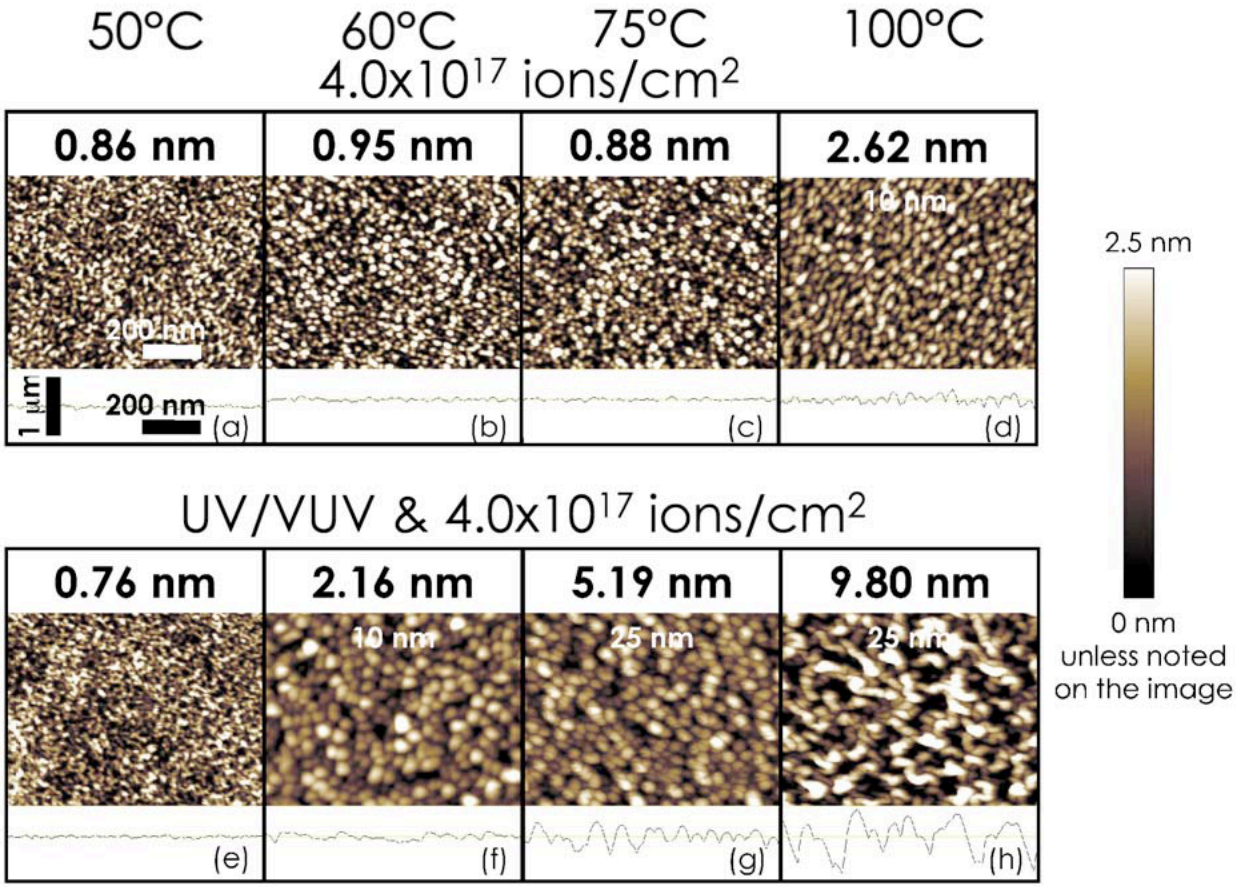




John designed *second* new vacuum beam system

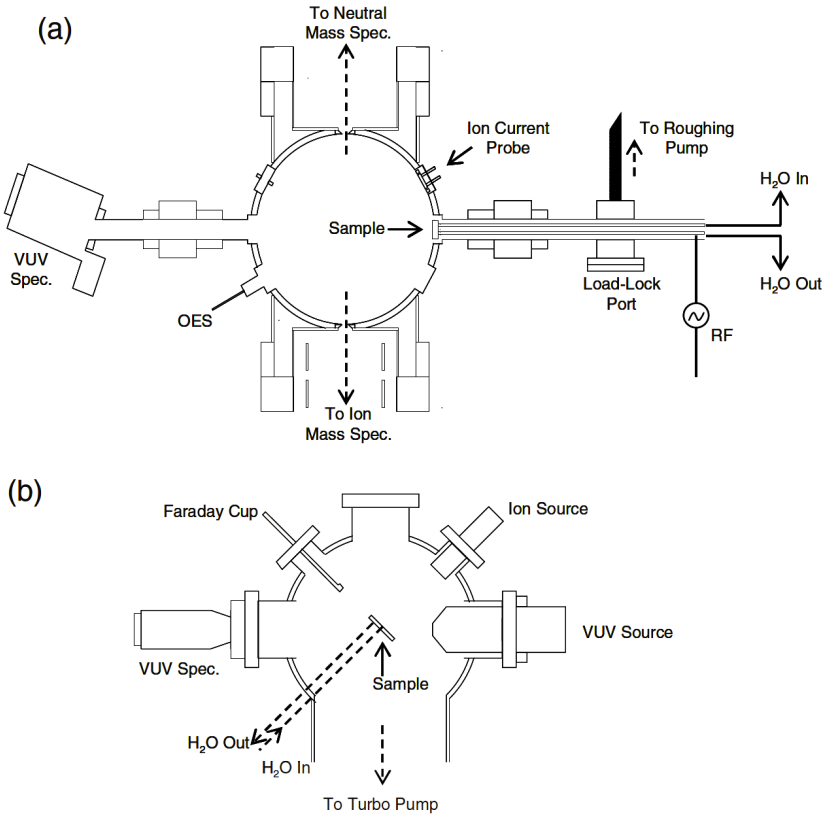
Dustin Nest

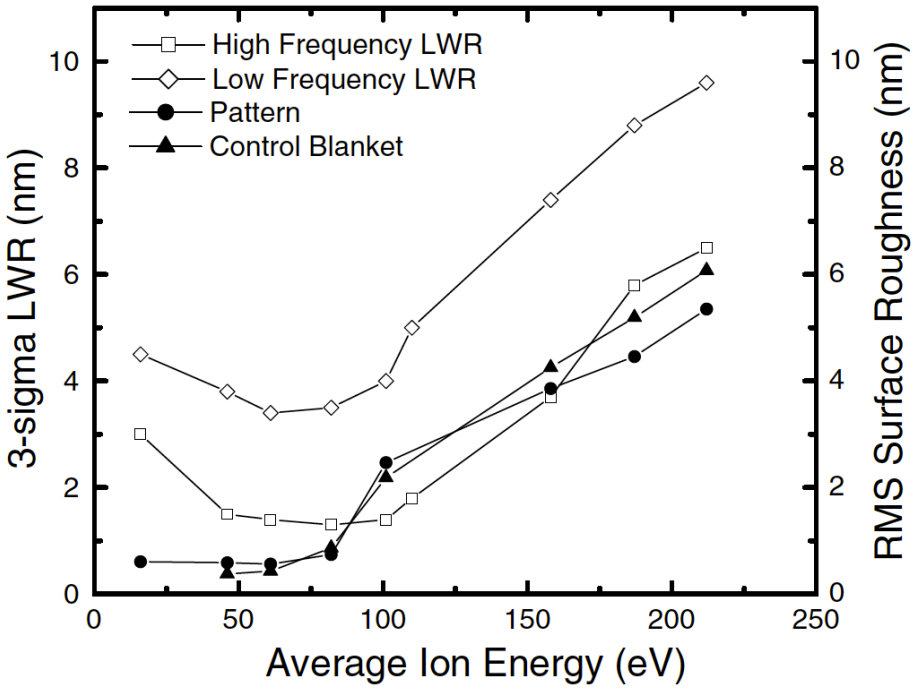
Pioneering vacuum beam study of ion-vacuum ultraviolet photon synergy in plasma-193 nm photoresist roughening.



Monica Titus

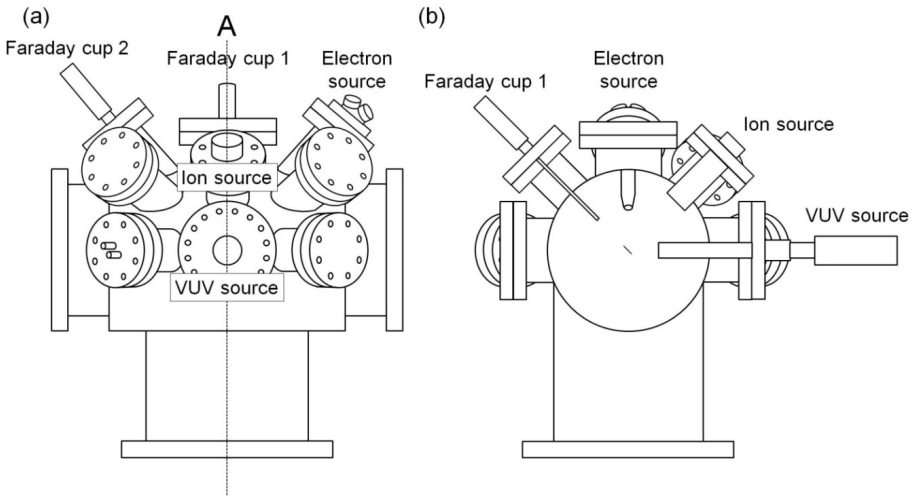
Experimental-modeling studies in ICPs: wafer-based diagnostics and ICP-vacuum beam comparisons for 193 nm PR roughening.

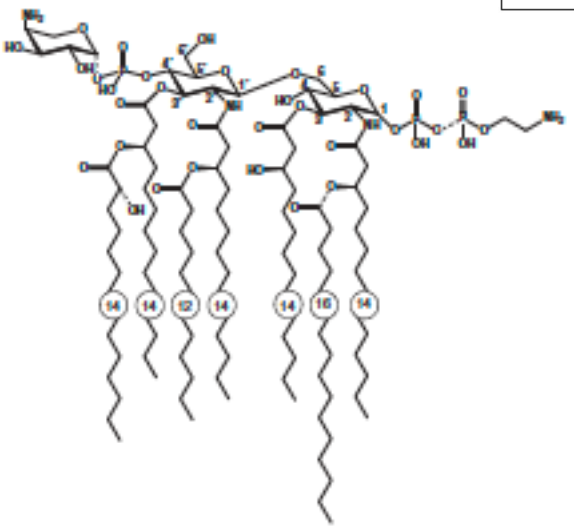


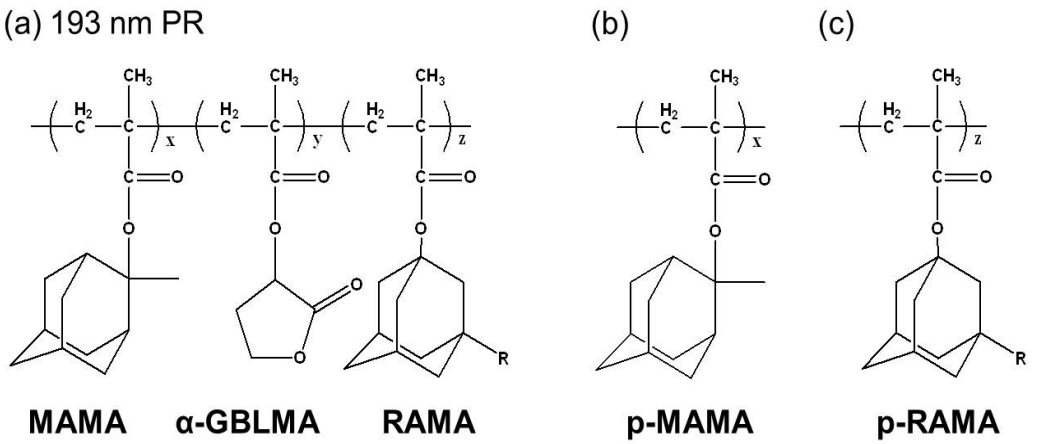


Ting-Ying Chung

Vacuum beam experiments on193 nm PR roughening and biomolecule inactivation via VUV photons and radicals







John Coburn: Colleague and Friend

John was a unique individual – a combination of scientific skill and intellectual rigor made John one of the leading scientists in plasma- and plasma-surface science in the 20th century.

No less important were John's remarkable personal characteristics: He was extraordinarily able to understand and help others, and he was one of the best teachers I have ever known – a real role model.

I will miss him dearly.