

# Vacuum References

---

## TABLE OF CONTENTS

VACUUM TECHNOLOGY BOOKS .....	2
RESIDUAL GAS ANALYSIS .....	2
APPLICATIONS OF RESIDUAL GAS ANALYZERS TO PROCESS/QUALITY CONTROL .....	4
SPECIALIZED/UNUSUAL APPLICATIONS OF RGAS .....	7
HIGH PRESSURE SAMPLING/ DIFFERENTIAL PUMPING.....	8
QUANTITATIVE MEASUREMENTS WITH RESIDUAL GAS ANALYZERS .....	9
MULTIPLE LINEAR REGRESSION ANALYSIS ALGORITHMS .....	10
VACUUM SYSTEM DESIGN .....	10
VACUUM SYSTEM CONTAMINATION .....	14
VACUUM PUMPS.....	17
TOTAL PRESSURE MEASUREMENT .....	20
BAYARD-ALPERT IONIZATION GAUGES .....	21
PIRANI/THERMOCOUPLE GAUGES .....	24
PRESSURE CALIBRATION/SPINNING ROTOR GAUGE .....	25
TEMPERATURE PROGRAMMED DESORPTION .....	26
MEMBRANE INTRODUCTION MASS SPECTROMETRY (MIMS) .....	28
VARIABLE LEAK VALVES.....	28
VACUUM AND PROCESS CONTROL PUBLICATIONS .....	29
VACUUM AND PROCESS CONTROL WEBSITES .....	30

# Vacuum Technology Books

1. J. M. Lafferty , editor, “Foundations of Vacuum Science and Technology”, John Wiley and Sons, Inc., NY, 1998. **Note:** A great book that every vacuum practitioner should own.
2. J. H. Leck, “Total and Partial Pressure Measurement in Vacuum Systems”, Blackie, Glasgow&London, 1989. **Note:** Another classic. Great chapters on gauging.
3. Armand Berman, “Total Pressure Measurements in Vacuum Technology”, Academic Press, Orlando, FL, 1985
4. J. F. O’Hanlon, “A user’s guide to Vacuum Technology”, 2<sup>nd</sup>. Ed. , Wiley, NY, 1989.
5. Gerhard Lewin, “An Elementary Introduction to Vacuum Technique”, AVS Monograph Series, American Institute of Physics, Inc. NY, NY, 1987. **Note:** Great Little reference book.
6. John H. Moore et. al. , “Building Scientific Apparatus: A Practical Guide to Design and Construction, 2<sup>nd</sup> edition”, Addison Wesley, Redwood City, CA, 1989. **Note:** Every science research laboratory must have a copy of this book on its shelves. The Vacuum Technology chapter (Chapter 3, p. 75) provides one of the best introductions to vacuum technology and vacuum system design we have ever seen!
7. Walter H. Kohl, “Handbook of Materials and Techniques for Vacuum Devices”, American Vacuum Society Classics, AIP Press, New York, 1995.
8. Phil Danielson, “Building a Vacuum Library”, R&D, March 2002, p. 34

# Residual Gas Analysis

1. Dawson, “Quadrupole Mass Spectrometry and Its Applications”, AIP Press, NY, 1995.
2. Drinkwine and D. Lichtman, “Partial Pressure Analyzers and Analysis”, AVS Monograph Series published by the Education Committee of the American Vacuum Society. <http://www.avs.org>.
3. Anne B. Giordani et. al., “What is Mass Spectrometry?”, 1998, a supplement to the Journal of the American Society of Mass Spectrometry. <http://www.asms.org>.
4. Basford et. al., J. Vac. Sci. Technol. A 11(3) (1993) A22-40: “Recommended Practice for the Calibration of Mass Spectrometers for Partial Pressure Analysis. Update to AVS Standard 2.3”. <http://www.avs.org>
5. Batey, Vacuum, 37 (1987) 659-668:” Quadrupole Gas Analyzers”
6. Fu Ming Mao et. al., Vacuum, 37 (1987) 669-675: “ The quadrupole mass spectrometer in practical operation”

7. Dawson, Mass Spectrometry Reviews, 5 (1986) 1-37: "Quadrupole mass analyzers: Performance, design, and some recent applications"
8. Austin et. al., Vacuum 41(1990)2001, "Optimization of the operation of the small quadrupole mass spectrometer to give minimum long-term instability"
9. M. G. Rao and C. Dong, J. Vac. Sci. Technol. A 15(3) (1997) 1312, "Evaluation of low cost residual gas analyzers for ultrahigh vacuum applications". **Note:** The RGA models in this paper are: **A: MKS PPT 050EM, B: SRS 100 AMU with electron multiplier, C: MKS PPT 200EM, D: Balzers QMS 200 M, E: Leybold Inficon High performance Transpector H100M** as indicated by the authors.
10. S. Daolio, et. al., "Quadrupole Secondary Ion Mass Spectrometer for Simultaneous Detection of Positive and Negative Ions", Rapid. Commun. Mass Spectrom. 13 (1999) 782-785
11. Changkung Dong and G. Rao Myneni, "Field emitter based extractor gauges and residual gas analyzers", J. Vac. Sci. Technol. A17(4) (1999) 2026. **Note:** An **SRS RGA** was retrofitted with a Spindt-type field emitter array. Residual gas spectra indicate reduced O, Cl and F electron stimulated desorption.
12. Shue Watanabe, Hitoshi Oyama, Shigeki Kato and Masakazu Aono, "Measurement of partial pressures in extremely high vacuum region using a modified residual gas analyzer", Rev. Sci. Instr. 70 (1999) 1880
13. T. E. Felter, "Cold cathode emitter array on a quadrupole mass spectrometer: Route to miniaturization", J. Vac. Sci. Technol. B 17(5), Sept/Oct 1999, p. 1993
14. J. H. Batey, "Thermal Desorption from mass spectrometer filaments", Vacuum 43(1) (1992) 15
15. J. R. Gibson, S. Taylor and J. H. Leck, "Detailed simulation of mass spectra for quadrupole mass spectrometer systems", J. Vac. Sci. Technol. A 18(1) (2000) 237
16. Ma'an H. Amad and R. S. Houk, "Mass resolution of 11,000 to 22,000 with a multiple pass Quadrupole mass analyzer", J. Am. Soc. Mass Spectrom. 11 (2000) 407. **Note:** Very clever way to get awesome resolution out of a small Quad.
17. J. R. Gibson and Stephen Taylor, "Prediction of quadrupole mass filter performance for hyperbolic and circular cross section electrodes", Rapid Communications in Mass Spectrometry, 14 (2000) 1669. **Note:** Improved computational method used to calculate throughput of quadrupole filters with circular and hyperbolic shaped rods.
18. Sharon Lewis, "Simplifying the Residual Gas Analyzer", R&D Magazine, October 2000, p. 21.
19. S. Boumsellek and R. J. Ferran, "Trade Offs in Miniature Quadrupole Designs", J. Am. Soc. Mass Spectrom. 12 (2001) 633. **Note:** A complete article describing the inherent advantages and limitations of small quadrupole designs.

20. Gerardo A. Brucker, "How to use an RGA", R&D Magazine, June 2001, p. 13.
21. Bob Langley and Paul LaMarche, "Mass Spectrometer Basics and Operation", Vacuum Technology and Coating, Oct. 2002. P. 20.
22. Ethan Badman, R. Graham Cooks, "Miniature Mass Analyzers", J. Mass Spectrom. 35 (2000)659
23. S. Taylor et.al., "A miniature mass spectrometer for chemical and biological sensing", Proc. SPIE 4036 (2000) 187.
24. B. Wilamowski, et.al., "Enhancing the sensitivity of miniaturized mass spectrometers", IECON'01, 27<sup>th</sup> Annual Conference of the IEEE Industrial Electronics Society, p. 147.
25. Phil Danielson, "Will RGAs Replace Ion Gauges?", R&D Magazine, June 2003, p. 31. Note: Is an Ion Gauge good enough? When is an RGA required? Phil Danielson joins this long-standing debate...
26. Vladimir I. Baranov, "Analytical Approach for Description of Ion Motion in QMS", J. Am. Soc. Mass Spectrom. 14 (2003) 818.
27. Vladimir I. Baranov, "Analytical approach for description of Ion Motion in Quadrupole Mass Spectrometer", J. Am. Soc. Mass Spectrom. 14 (2003) 818-824

## Applications of Residual Gas Analyzers to Process/Quality Control

1. O'Hanlon, J. Vac. Sci. Technol. A 12 (4), Jul/Aug 1994: "Ultrahigh vacuum in the semiconductor industry"
2. Vic Comello, R&D Magazine, September 1993, p. 65: "Process Monitoring with "Smart" RGAs"
3. Waits, et. al., Semiconductor International, May 1994, p. 79: "Controlling your Vacuum Process: Effective Use of a QMA"
4. Rosenberg, Semiconductor International, October 1995, p. 149: "The Advantages of Continuous On-line RGA Monitoring".
5. Lakeman, Semiconductor International. October 1995, p. 127: "Increase overall Equipment Effectiveness with In Situ Mass Spectrometry".
6. Semiconductor International Magazine, October 1995, p. 70, "Researchers Demonstrate Viability of QMS for In Situ Diagnostics"
7. L.L. Tedder, et. al., J. Vac. Sci. Technol. B, 13(4) (1995) 1924, "Real-time process and product diagnostics in rapid thermal chemical vapor deposition using in situ mass spectrometry sampling"

8. C. D' Couto and Sanjay Tripathi, Semiconductor International, July 1996, p. 343, "Residual Gas Analysis Suggests Process Improvement"
9. R. W. Rosenberg, Semiconductor International, October 1995, p. 149, "The Advantages of Continuous On-line RGA Monitoring"
10. Vic Comello, "Using RGAs for Process Monitoring", R&D Magazine, October 1997, p. 33. ("Back to Basics" article)
11. Vic Comello, "RGAs Provide Real Time Process Control", Semiconductor International, September 1990.
12. P. Ausloos et. al., "The Critical Evaluation of a Comprehensive Mass Spectral Library", J. Am. Soc. Mass Spec., 10 (1999) 287-299.
13. Robert Waits, "Semiconductor and thin film applications of a quadrupole mass spectrometer", J. Vac. Sci. Technol. A 17(4) (1999) 1469. **Note:** A very good paper on applications of mass spectrometers to semiconductor processes. Highly recommended, probably required, reading!
14. Guangquan Lu, Laura L. Tedder and Gary W. Rubloff, "Process sensing and metrology in gate oxide growth by rapid thermal chemical vapor deposition from SiH<sub>4</sub> and N<sub>2</sub>O", J. Vac. Sci. Technol. B17(4) (1999) 1417
15. Brian Dickson, et. al., "Vacuum-based Process Toll Diagnostics: How to expose trends and problems that the tolls themselves cannot detect", Vacuum and ThinFilm, August 1999, p.30
16. T. P. Schneider et. al., "Real-time in situ residual gas monitoring", FUTURE FAB International, issue 4, volume 1, p.237.
17. A. G. Chakhovskoi, C. E. Hunt, M.E. Malinowski, "Gas Desorption electron stimulated during operation of field emitter-phosphor screen pairs", Displays, 19 (1999) 179-184
18. Xi Li et. al., "Mass Spectrometric measurements on inductively coupled fluorocarbon plasmas: Positive Ions, Radicals, and Endpoint Detection", J. Vac. Sci. Technol. A17(5) (1999) 2438
19. Jim Snow, Stuart Tison and Walter Plante, "Evolving gas flow, measurement, and control technologies", Solid State Technology, October 1999, p. 51.
20. Paul Espitalier-Noel, "Integrate gas, chemical, vacuum, and exhaust design", Solid State Technology, Oct. 1999, p. 65
21. Charles C. Allgood, "Impact and behavior of trace contaminants in high purity plasma process gases", Solid State Technology, Sept. 1999, p. 63
22. K. C. Lin, "Continuous Gas Monitoring Reduces Losses", Semiconductor International, May 1999.

23. Babu R. Chalamala, David Uebelhoer and Kenneth A. Dean, "Apparatus for quantitative analysis of residual gases in flat panel vacuum packages", J. Vac. Sci. Technol. A 18(2) (2000) 1. **Note:** Uses and **SRS RGA300** for quantitative analysis of residual gases in flat panel displays.
24. Robert K. Waits, "Monitoring residual and process gases in PVD processes: The importance of sensitivity", MICRO Magazine, June 1997, p. 81. **Note:** A great article including useful information on the effects of contaminants on sputter deposited films.
25. Russ Carr, "Sensor Automates Detection of Photoresist Residues", R&D Magazine, March 2000, p. 51
26. Robert Waits, "Evolution of integrated-circuit vacuum processes: 1959-1975", JVST A 18(4) (2000) 1736.
27. C. B. Yarling "History of Industrial and commercial ion implantation: 1906-1978", JVST A 18 (4) (2000) 1746.
28. Thomas P. Schneider et. al. , "Using partial pressure analysis to monitor wet clean recovery", Solid State Technology, August 2000, p. 117
29. Donald M. Mattox, "Applications of Vacuum Coating", Vacuum Technology and Coating, May 2001, p. 16.
30. Surajed Promreuk, "Achieving process understanding and real-time fault detection on a PVD toll", MICRO Magazine, March 2002, p. 45.
31. Steve Whitten, et. al., "Investigating an integrated approach to etch emissions management", MICRO, March 2002, p. 83.
32. Peter Rosenthal, "Gas Analysis Solutions for Yield Improvement of Deposition Processes for LEDs and Large Area Coatings Applications", Vacuum Technology and Coating, July 2003, p. 26. **Note:** It includes FTIR and Micropole Technology.

---

## Specialized/Unusual Applications of RGAs

1. Don Hall, Wells Shentwu, S. Michael Sterner, and Paul D. Wagner, 1997, "Using Fluid Inclusions to Explore for Oil and Gas", *Hart's Petroleum Engineer International*, No. 11, p. 29-34. **Note:** SRS RGAs used to examine fluid inclusions from oil wells.
2. Hadley, Scott W., Don L. Hall, S. Michael Sterner, and Wells Shentwu, 1997, "Hydrocarbon Pay Delineation and Product Characterization with Fluid Inclusions: Examples from East Coast Canada and Western Canada Sedimentary Basin", in *Can. Well Log. Soc. in site*, Vol. 1, No. 3, p.2-4. **Note:** **SRS RGA** s used to examine fluid inclusions from oil wells.
3. Harmeet Singh, et. al. "Mass spectrometric detection of reactive neutral species: Beam-to-background ratio", *J. Vac. Sci. Technol.* A17(5) (1999) 2447
4. Harmeet Singh, J. W. Coburn and David B. Graves, "Appearance potential mass spectrometry: Discrimination of Dissociative ionization products", *J. Vac. Sci. Technol.* A18(2) (2000) 299
5. Babu Chalamala, Robert Wallace and Bruce Gnade, "Poisoning of Spindt-type molybdenum field emitter arrays by CO<sub>2</sub>", *J. Vac. Sci. Technol.* B 16(5) (1998) 2866. **Note:** SRS RGA100 is used in the study of the effect of CO<sub>2</sub> on the emission characteristics of Spindt-type molybdenum field emission cathode arrays.
6. O. David Sparkman, "The 12<sup>th</sup> Sanibel Conference on Mass Spectrometry: Field-Portable and Miniature Mass Spectrometry", *J. Am. Soc. Mass Spectrom.* 11 (2000) 468. **Note:** An interesting review of field portable mass spectrometry.
7. Scott A. Furman et. al., "Improving the detection limit of a quadrupole mass spectrometer", *J. Vac. Sci. Technol.* A 19(3) (2001) 1032.
8. D. R. Ermer, et. al. "Intensity Dependence of Cation Kinetic Energies from 2,5-dihydroxybenzoic acid near the infrared matrix-assisted laser desorption/ionization threshold", *Journal of Mass Spectrometry*, 36 (2001) . **Note:** An SRS RGA is used in a TOF setup to determine the mechanism of Ionization of MALDI Matrices. Reprint kindly submitted by professor Richard Haglund, Jr.
9. R. T. Short et. al. , "Underwater Mass Spectrometers for in situ Chemical analysis of the Hydrosphere", *J. Am. Soc. Mass Spectrom.* 12 (2001) 676. **Note:** An RGA is used in combination with Membrane Introduction Mass Spectrometry to do underwater analysis of VOCs.
10. Colin S. Creaser, David Gomez Lamarca, Jeffrey Brum, Christopher Werner, Anthony P. New and Luisa M. Freitas dos Santos, "Reversed-Phase Membrane Inlet Mass Spectrometry Applied to the Real-Time Monitoring of Low Molecular Weight Alcohols in Chloroform", *Anal. Chem.* 74(2002) 300-304. **NOTE:** A **SRS QMS300** is used to perform real-time MIMS determinations of alcohols in chloroform. RGAs are rapidly gaining acceptance in this field as their excellent price/performance value is realized by MIMS practitioners

11. N. Takahashi et. al., "Development of the quadrupole mass spectrometer with the Bessel-Box type energy analyzer: Function of the energy analyzer in the partial pressure measurements", J. Vac. Sci. Technol. A 19(4) (2001) 1688
12. H. G. Buhner, et.al., "Investigating the curing of amino resins with TGA-MS and TGA-FTIR", UserCom, 2/2001, p. 13. ; Cyril Darribere, "TGA-FTIR and TGA-MS measurements", UserCom, 2/2001, p. 21. Note: UserCom is a publication of METTLER TOLEDO (www.mettler.com), specialized in thermal analysis products including Thermal Gravimetric Analysis and Differential Scanning Calorimetry. RGAs have recently been interfaced to TGA analyzers providing confirmation of the nature of the species outgassed by the sample during the heating cycle.
13. C. Richard Arkin, et. al., "Evaluation of Small Mass Spectrometer Systems for Permanent Gas Analysis", J. Am. Soc. Mass Spec. 13 (2002) 1004. Note: The **SRS RGA100** is compared to several commercial (i.e. Leybold XPR-2 and Ferran Micropole) and research mass specs and found to be the best match for the analysis of cryogenic fuels around the Space Shuttle. This paper demonstrates the excellent accuracy, reproducibility and detectability of gas analysis systems based on **SRS RGAs**.
14. V. A. Shamamian et. al. "Mass Aspectrometric Characterization of Pulsed plasmas for deposition of thin polyethylene Glycol-like Polymer films", Vacuum Technology and Coating, September 2002, p. 40.
15. Jorge Diaz, Clayton Giese and W. R. Gentry, "Mass Spectrometry for in-situ volcanic gas monitoring", trends in analytical chemistry, vol. 21, no. 8, 2002. Note: A QMS300 is used to monitor volcanic gases in-situ. Includes cool pictures of a QMS300 on top of the Kilauea Volcano in Hawaii.
16. Paul LaMarche and Bob Langley, "Dial V for Vacuum", Vacuum Technology and Coating, March 2003, p. 18. Note: This article describes the practical use of RGAs for Leak Testing.
17. Marcus B. Wise, Michael R. Guerin, "Direct Sampling Mass Spectrometry", Anal. Chem., News and Features, Jan 1, 1997, p. 26A. Note: This is a great paper on all the ways in which mass specs are used to provide real time data for environmental screening. This is very relevant for QMS system users.
18. Gerardo A. Brucker, "What Else Can a RGA Do?", Vacuum Technology and Coating, July 2003, p. 36.

## **High Pressure Sampling/ Differential Pumping**

1. Gilbert R. Smith and Robert R. Gidner, Semiconductor International, "Innovative Gas Handling Technology", June 1997, p. 125
2. Haripov F., J. Vac. Sci. Technol. A 15(4) (1997) 2434, "Rarefied gas flow through a long tube at arbitrary pressure and temperature drops"

3. Batey J. H. Vacuum 44 (5-7) (1993) 639, "Fractionation in gas inlets for PPA calibration"
4. Toshio Takiya, Fumio Higashino, Y. Terada, and A. Komura, "Pressure Wave propagation by gas expansion in a high vacuum tube", J. Vac. Sci. Technol. A 17(4) (1999) 2059
5. Felix Shapiro, "Rarefied gas flow through a long rectangular channel", J. Vac. Sci. Technol. A 17(5) (1999) 3062
6. Seksan Dheandhanoo, et. al., "Atmospheric Pressure Sample Inlet for Mass Spectrometers", Rev. Sci. Instr. 71 (2000) 4655. Note: a very versatile direct sample introduction inlet for atmospheric sampling.
7. I. E. Sodal and D. A. Hanna, "Improved mass spectrometer measurements using a pulsed gas sampling system", J. Vac. Sci. Technol. A 15(1) (1997) 176.

## Quantitative Measurements with Residual Gas Analyzers

1. Bley, Vacuum, 38 (1988) 103-109: "Quantitative measurements with quadrupole mass spectrometers: important specifications for reliable measurements"
2. Cowen, et. al., J. Vac. Sci. Technol. A 12(1), Jan/Feb 1994: "Non-linearities in sensitivity of quadrupole partial pressure analyzers operating at higher pressures"
3. L. J. Kieffer, et. al., Reviews of Modern Physics, 38(1) (1996) 1, "Electron Impact Ionization cross-section Data for Atoms, Atomic Ions, and Diatomic Molecules: I. Experimental Data"
4. NIST Database: Electron Impact Ionization Cross Sections, Y-K. Kim, et. al., on-line version: <http://physics.nist.gov/PhysRefData/Ionization/Xsection.html>.
5. R. A. Ketola, et. al., Rapid Comm. Mass Spectrom. 13 (1999) 654-662, "A Non-Linear Asymmetric Error Function based Least Mean Square Approach for the Analysis of Multicomponent Mass Spectra Measured by Membrane Inlet Mass Spectrometry"
6. P. J. Abbott et. al. JVST A14(3) (1996) 1242, "Commercial helium permeation leak standards: Their properties and reliability".
7. Kimo Welch, "Calibrating Partial Pressure Gauges. A learning experience", Vacuum Technology and Coating, Nov/Dec 2000, p. 40. Note: A typical Kimo paper. Full of down-to-earth, "don't do what I did", kind of knowledge.
8. C. Richard Arkin, et. al., "Evaluation of Small Mass Spectrometer Systems for Permanent Gas Analysis", J. Am. Soc. Mass Spec. 13 (2002) 1004. Note: The **SRS RGA100** is compared to several commercial (i.e. Leybold XPR-2 and Ferran Micropole) and research mass specs and found to be the best match for the analysis

of cryogenic fuels around the Space Shuttle. This paper demonstrates the excellent accuracy, reproducibility and detectability of gas analysis systems based on **SRS RGAs**.

9. Andrew K. Ottens, W.W. Harrison, Timothy P. Griffin, and William Helms, "Real time Quantitative Analysis of H<sub>2</sub>, He, O<sub>2</sub> and Ar by Quadrupole Ion Trap Mass Spectrometry", JASMS 13(2002) 1120. Note: An **SRS RGA** is used as the standard to check the ion trap results.
10. B. R. F. Kendall, "Pulsed Gas injection for on-line calibration of residual gas analyzers", J. Vac. Sci. Technol. A 5(1)(1987) 143.

## **Multiple Linear Regression Analysis Algorithms**

1. William H. Press, et. al., 1992, Numerical Recipes in C, The Art of Scientific Computing, Second Edition, Cambridge Univ. Press, section 15.4, page 671.
2. Bevington, P.R., 1969, Data Reduction and Error Analysis for the Physical Sciences, New York, McGraw-Hill, Chapters 8-9.

## **Vacuum System Design**

1. J. M. Lafferty, "Foundations of Vacuum Science and Technology", John Wiley & Sons, New York, 1997. **Note:** this is, by far, the most useful book on vacuum related matters your money can buy!
2. Gerhard Lewin, "An elementary introduction to vacuum technique", AVS Monograph Series published by the Education Committee of the American Vacuum Society.
3. John T. Yates, "Experimental Innovations in Surface Science. A guide to Practical Laboratory Methods and Instruments", Springer-Verlag, New York, 1997. **Note:** This is an excellent book, with lots of great practical ideas! We highly recommend it.
4. Studt, R&D Magazine, October 1991, p. 104: "Design Away Those Tough Vacuum System Riddles". Note: Read this one! Make a copy and hang it on your wall!
5. Phil Danielson, Vacuum & ThinFilm, Oct. 1998, "Gas Loads in Vacuum Systems", p. 37, and "The Value of PumpDown Curves", p. 12.
6. Phil Danielson, Vacuum & ThinFilm, Nov/Dec. 1998, "Rate-of -rise Measurements", p. 12.
7. Phil Danielson, Vacuum & ThinFilm, March 1999, "Gas Load and Effective Pumping Speed", p. 12, and "Creating a Vacuum", p. 34.
8. Vic Comello, "Metal-Sealed Components Are Not Just for UHV Anymore", R&D Magazine, October 1997, p. 24.

9. Glen Tisdale et. al., Solid State Technology, May 1998, "Next Generation Aluminum Vacuum Systems"
10. P. R. McCabe et. al., J. Vac. Sci. and Technol., A 17 (2) (1999) 673, "A convenient means of securing gaskets during assembly of vertically oriented knife-edge flanges"
11. Hugh Everson, "From Scrap Metal to Vacuum Components", Vacuum Solutions March/April 1999.
12. Phil Danielson, Vacuum and Thin Film, May 1999, p. 10, " Gas Flow Rates: Volume Flow and Mass Flow".
13. Vic Comello, "Taking Vacuum Valves Seriously", R&D Magazine, March 1998, p. 61.
14. Phil Danielson, Vacuum and Thin Film, June 1999, p. 12, " Gas Loads from Virtual Leaks".
15. Phil Danielson, Vacuum and Thin Film, July 1999, p. 18, " Why Create a Vacuum? How physical and chemical factors affect molecular activity."
16. V. S. Smentkowski and A. L. Linsebigler, " Stabilization of long travel-single bellows-horizontal manipulators", J. Vac. Sci. Technol. A17(4) (1999) 2056
17. H.F. Dylla et. al., "Design and installation of a low particulate, ultrahigh vacuum system for a high power free-electron laser, J. Vac. Sci. Technol. A 17(4) (1999) 2113
18. Phil Danielson, "Advances in Vacuum Sealing", Vacuum & Thin Film, Sept. 1999, p. 8
19. Ian Stevenson et. al., "Choosing a Chamber, Various Functions to Consider", Vacuum & Thin Film, Sept. 1999, p. 23
20. Mike Ackeret, "Manipulators in a Vacuum: The challenge of manipulating samples in a controlled, ultra-clean or vacuum environment", Vacuum & Thin Film, Sept. 1999, p. 31
21. Vic Comello, "Do's and Don'ts of Designing UHV Chambers", R&D Magazine, October 1999, p. 18.
22. Phil Danielson, "The Vacuum Chamber-Volume or Surface Area?", Vacuum&ThinFilm, October 1999, p. 8.
23. S. G. Lee and J. G. Bak, "A vacuum chamber with a radial rotating port", Rev. Sci. Instr. 70 (1999) 4437
24. A. Noble and M. Kasevich, "UHV optical window seal to conflat knife edge" Rev. Sci. Instrum. 65(9) (1994) 3042

25. E.V. Alonso, et al., "Low Cost, Simple Gate Valve", Rev. Sci. Instr. 66 (3) (1995) 2738.
26. S. Kurokouchi, "Influence of lubricating conditions of fixing bolts on penetration of Conflat flange knife edge into gasket", J. Vac. Sci. Technol. A18(1) (2000) 288
27. W. F. Smith, B. G. Stokes and J. F. Crawford, "Cryogenic substrate cooling or substrate heating without vacuum feedthrus", J. Vac. Sci. Technol. A 18(1) (2000) 290
28. Y. Suetsugu, et al. "Development of an all-metal vacuum bellows following twist motion", J. Vac. Sci. Technol. A 17(6) (1999) 3500
29. P. R. McCabe and A. L. Utz, "Low cost alternative to motorized linear and rotary motion feedthroughs", J. Vac. Sci. Technol. A 17(6) (1999) 3529
30. "What is a vacuum?", Vacuum Technology & Coating, JAN/FEB 2000, p. 12. A reminder of what vacuum is all about and what it takes to accomplish it.
31. R. Moreh and Y. Finkelstein, "A practical all-metal flange-seal for high and low temperatures", Rev. Sci. Instr. 71(2) (2000) 591
32. Peter Geng et al., "A compact UHV system for the in-situ investigation of III/V semiconductor surfaces", Rev. Sci. Instr. 71(2) (2000) 504
33. Norbert Pocheim, "Throttle Valve Reduces Cost of Ownership", R&D Mag. Feb. 2000, p. 65.
34. M. McKeown, "What you should know about traps, valves and gauges", Semiconductor International, March 1991, p. 109.
35. M. Lenzen and R.E. Collins, "Hermetic indium metal-to-glass tube seal", J. Vac. Sci. Technol A18(2) (2000) 552.
36. Adam M. Hawkrige et al. "Cryogenic ultrahigh vacuum manipulator for angle dependent x-ray photoelectron spectroscopy studies", J. Vac. Sci. Technol. A 18(2) (2000)567.
37. William Wuertz, "Welding system Improves Quality Assurance", R&D Magazine, March 2000, p. 26. Note: Orbital TIG Welders let you weld tubes all by yourself!
38. Rich Combs, "New RF Feedthrus Minimize Coupling Effects", R&D Magazine, March 2000, p. 47.
39. Kimo M. Welch, "Finger Ponting in the FAB", Vacuum Technology and Coating, May 2000, p. 12-16.
40. Gerald Murphy and Kathryn Whitenack, "Chilled Water Options Vary for Laboratory Equipment", R&D Magazine, May 2000, p. 55.

41. Vic Comello, "Viewport Shutter Designs Meet Deposition Requirements", R&D Mag. June 2000, p. 87.
42. C. Biscardi, et. al. "Application of Porcelain Enamel as an UHV-compatible electrical insulator", JVST A 18(4) (2000) 1751.
43. Vincenc Nemanic et. al. "Experiments with a thin walled stainless steel vacuum chamber", JVST A 18(4) (2000) 1789.
44. Phil Danielson, "Improve your vacuum system performance and behavior", R&D Magazine, August 2000, p.39.
45. Kaveh H. Zarkar, et. al. "Designing High-Performance Vacuum Control Systems", R&D Magazine, Sept 2000, S-3.
46. Phil Danielson, "Assessing Gas Loads in Vacuum System Design", R&D Magazine, Oct. 2000, p. 39
47. Dan Goodman et. al., "Etch and CVD process improvements via heated vacuum throttle valves", Solid State Technology, December 2000, p. 80.
48. Boude C. Moore, "Thin-walled chambers of austenitic steel", J. Vac. Sci. Technol. A 19(1) (2001) 228.
49. Z. Celinski, "Molecular Beam epitaxy system at an undergraduate institution", J. Vac. Sci. Technol. A 19(1) (2001) 383.
50. D. L. Miller et. al., "All metal ultrahigh vacuum optical fiber feedthru", J. Vac. Sci. Technol. A 19(1) (2001) 386.
51. Phil Danielson, "How to Use the  $Q = S P$  Vacuum Relationship", R&D Magazine, March 2001, p. 33.
52. Donald Mattox, "Safety Aspects of Vacuum Processing", Vacuum Technology and Coating, March 2001, p. 22.
53. Gerardo Brucker, "Prevention is Key to Vacuum System Safety", R&D Magazine, Feb. 2001, p.57.
54. Kimo Welch, "All-Metal Vacuum Seals", Vacuum Technology and Coating, May 2001, p. 6; also "More on all-metal seals", Vacuum Technology and Coating, June 2001, p. 12.
55. Donald Mattox, "Steady State and Transient Conductance", Vacuum Technology and Coating, June 2001, p. 20.
56. Lawrence Lamont Jr., "Thin Film PVD and strategies for optimized UHV-XHV pumping", Solid State Technology, July 2001, p. 81
57. Ray Dubois and James Mayer, "Safety Solutions for High Pressure Gas Cylinders", Solid State Technology, July 2001, p. 153.

58. M. Mapes. "Summary of Quick Disconnect vacuum flanges", J. Vac. Sci. Technol. A19(4) (2001) 1693.
59. Phil Danielson, "Molecular Flux Provides Process Understanding", R&D Mag., August 2001, p.65.
60. Phil Danielson, "Vacuum Envelope Penetration", R&D Magazine, September 2001, p. 82.
61. John Baxter, "Gas Delivery Systems Undergo Radical Design Modifications", R&D Magazine, Oct. 2001, p. 36
62. Ping Li, "Dynamic Sealing Using "Ferrofluidic", Vacuum Technology and Coating, November 2001, p. 32
63. S. Kurokouchi, et. al., "Characteristics of a Taper seal type gasket for the Conflat Sealing System", J. Vac. Sci. Technol., A 19(6) (2001) 2963. Note: A novel way to seal Conflats . Worth checking out and keeping in mind.
64. Amara Rozgus, "Vacuum Users Think Outside the Box", R&D Magazine, Oct. 2002, p. 26.
65. Paul LaMarche and Bob Langley, "Movement in Vacuum", Vacuum Technology and coating, Nov. 2002, p. 26. Note: Information on vacuum compatible actuated devices.
66. P. LaMarche and Bob Langley, "Vacuum Vessel Fabrication", Vacuum technology and Coating, Jan 2003, p. 26.
67. Stan Kassela, "Improving fab productivity with predictive vacuum maintenance", Solid State Technology, Feb 2003, p.77.
68. Phil Danielson, "The Flavor Issue-How to Choose the Right Vacuum Materials", R&D Magazine, April 2003, p. 39-40.
69. Philip Lessard, "Vacuum Issues in the semiconductor Industry, Ion Implantation", Vacuum Technology and Coating, June 2003, p. 36.
70. Paul LaMarche and Bob Langley, "Gas Admission Systems", Vacuum Technology and Coating, July 2003, p. 18.
71. Phil Danielson, "Solving Process Problems at the Molecular Flux Level", R&D Magazine August 2003, p. 31.

## Vacuum System Contamination

1. Inkuyu Chun, et. al. , J. Vac. Sci. Technol. A 14(4) (1996) 2636, "Outgassing rate characteristic of a stainless steel extreme high vacuum system"

2. B. B. Dayton, J. Vac. Sci. Technol. A 13(2) (1995) 451, "Outgassing Rate of preconditioned vacuum systems after a short exposure to the atmosphere: Outgassing rate measurements on Viton-A and copper"
1. Vic Comello, R&D Magazine, March 1993, p. 57, "Cleansing your quadrupole, Cryopumps Enhance Low-Level Contamination Detection"
2. J. Gomez-Goni and A. G. Mathewson, J. Vac. Sci. Technol. A 15(6) (1997) 3093, "Temperature dependence of the electron induced gas desorption yields on stainless steel, copper and aluminum"
3. M. Bernardini, et. al., J. Vac. Sci. Technol. A 16(1) (1998) 188, "Air bake-out to reduce hydrogen outgassing from stainless steel"
4. Phil Danielson, Vacuum and Thin Film, January 1999, p. 14, " Gas Loads from elastomer seals".
5. Vic Comello, R&D Magazine, December 1998, p. 43, " Oil a Concern with Rotary Vane Pumps"
6. Phil Danielson, Vacuum & Thin Film Magazine, April 1999, p. 12, "Reducing Water Vapor, Problems with Dry Gas"
7. Vincent Nemanic, et. al., J. Vac. Sci. and Technol. A17(3) (1999) 1040, "Outgassing in Thin Wall Stainless Steel Cells"
8. K. Akaishi, "Solution of the outgassing equation for the pump down of an unbaked vacuum system", J. Vac. Sci. Technol. A17 (1) (1999) 229.
9. Fumio Watanabe and Maki Suemitsu, "Separation of ESD neutrals from outgassing originating from the grid surface of emission controlled gauges: Studies with a heated grid gage", J. Vac. Sci. Technol. A 17(6) (1999) 3467.
10. Vic Comello, R&D Magazine, July 1999, p. 24, "Controlling Downstream Contamination Can Be Profitable"
11. J. Busath and H.K. Chiu, "Simple Catalytic cell for restoring He leak detector sensitivity on vacuum systems with high D2 backgrounds", J. Vac. Sci. Technol. A 17(4) (1999) 2015
12. K. L. Holtrop, M. Hansink, and G. Kellman, "Outgassing tests on materials used in the DIII-D magnetic fusion Tokamak", J. Vac. Sci. Technol. A 17(4) (1999) 2064
13. Phil Danielson, "Backstreaming Traps", Vacuum & Thin Film, August 199, p. 8
14. David Hucknall, "The vagaries of vacuums", Vacuum Solutions, September/October 1999, p. 46. Note: Includes several factors that can compromise performance in high vacuum systems based on diffusion pumps.

15. P. A. Redhead, "Modeling the pump-down of reversibly adsorbed phase. I. Monolayer and submonolayer initial coverage", JVST A13(2) (1995) 467, and "II. Multilayer Coverage" A 13(6) (1995) 2791.
16. Jean-Pierre De Luca, "Calibrating a Leak Detector Easily and Accurately", R&D Magazine, April 2000, p. 95.
17. Greg A. Pfister, "Eliminating Seal Contamination in Semiconductor Process Equipment", Vacuum Technology & Coating, June 2000, p. 29.
18. L. Layden and D. Wadlow, "High Velocity carbon dioxide snow for cleaning vacuum system surfaces", J. Vac. Sci. Technol. A 8(5) (1990) 3881.
19. Phil Danielson, "Reduce Water Vapor in Vacuum Systems", R&D Magazine, September 2000, S-10.
20. Rita Mohanty, "Use of Getters in Hermetic Packages", Vacuum Technology and Coating, October 2000, p. 41.
21. Andrew D. Johnson, et.al., "Reducing PFC gas emissions from CVD chamber cleaning", Solid State Technology, December 2000, p. 103.
22. Mark Higgins, "High Sensitivity Leak Detection, Done Simply", Vacuum Technology & Coating, January 2001, p. 42.
23. Donald Mattox, "Water and Water Vapor", Vacuum Technology and Coating, Jan 2001, p. 58.
24. Phil Danielson, "Desorbing Water in Vacuum Systems: Bakeout or UV?", R&D Magazine, January 2001, p. 57.
25. Dave Laube, "Limitations of CO2 cleaning for Semiconductor Process Tools", A2C2 Magazine, February 2001, p. 9. (for general info on this article email: [info@a2c2.com](mailto:info@a2c2.com))
26. Phil Danielson, "Contamination Lurks in Vacuum Systems, Sources", R&D Magazine, May 2001, p. 45.
27. Phil Danielson, "Fight Humidity in your vacuum system", R&D Magazine, June 2001, p. 67.
28. Bob Langley and Paul LaMarche, "Cleaning of Parts For Use In Vacuum", Vacuum Technology and Coating, August 2001, p.6.
29. Phil Danielson, "Using Simple Tools to Avoid Vacuum Performance Problems", R&D Magazine, Dec 2001, p. 61. Note: This is an excellent explanation of how rate-of-rise and pumpdown curves can be used to characterize vacuum systems. IGC100 controllers offer front panel display of such curves, making system characterization very simple.

30. Donald M. Mattox, "Deposition Chambers and Vacuum-surface "Conditioning"", Vac. Techn. & Coating, Sept. 2002, p. 30.
31. P. A. Redhead, "Recommended practices for measuring and reporting outgassing data", J. Vac. Sci. Technol. A 29(5)(2002)1667. Note: This is another Redhead classic, this time recommending a set of uniform procedures for reporting outgassing data.
32. Donald Mattox, "Cleaning with CO<sub>2</sub>", Vacuum Technology and Coating, March 2003, p.62.

## Vacuum Pumps

1. M. H. Hablanian, J. Vac. Sci. Technol. A12(4) (1994) 897, "Throughput type pumps and ultrahigh vacuum"
2. Kimo H. Welch, J. Vac. Sci. Technol. A12(4) (1994) 915, "Some important developments in capture pumping technology in the last 40 years"
3. R&D Magazine, February 1995, p. 55, "Dry Mechanical Vacuum Pumps For Almost Any Application"
4. Vic Comello, R&D Magazine, October 1996, p. 41, "Turbodrag Pumps Offer Improved Throughput and Light Gas Compression"
5. Baliga J., Semiconductor International, October 1997, p. 86, "Vacuum Pump Designs Adjust to Harsher Conditions"
6. Vic Comello, R&D Magazine, June 1998, p. 79, "Why Hybrid Turbos Are Often Preferred"
7. Vic Comello, R&D Magazine, February 1999, p. 63, "Choosing a Diaphragm Pump for a Turbo"
8. Vic Comello, R&D Magazine, February 1998, p. 81, "Exhausting Process Gases Safely and Efficiently".
9. Roberto Giannantonio, et. al. , R&D Magazine, February 1998, p. 83, "Better Getters Help Vacuum Pumps Work Faster"
10. Eckhard Bez, Solid State Technology, March 1999, p. S3, "Advances in Oil Free Vacuum Pumps".
11. Eckhard Bez, VACUUM and THINFILM, June 1999, p. 30 , "Oil Sealed Vacuum Pumps. Reducing Energy Consumption"
12. Phil Danielson, VACUUM and THINFILM, July 1999, p. 8, "Backstreaming from Oil-sealed Pumps"

13. S. Nesterov, J. Vasiliev, L.C.Wagner and M. Boiarski, "Hydrogen Pumping simulation for cryopumps", J. Vac. Sci. Technol. A 17(4) (1999) 2099
14. Gary Ash, "Cryogenic High Vacuum Pumps: An overview of their application and use", Vacuum&ThinFilm, August 1999, p. 20.
15. Phil Danielson, "Cryopump Crossover", Vacuum&ThinFilm, November 1999, p. 8
16. Vic Comello, "Tailoring Traps to Specific applications", R&D Magazine, January 2000, p. 59
17. I. Akutsu and T. Ohmi, "Innovation of the fore pump and roughing pump for high-gas-flow semiconductor processing", J. Vac. Sci. Technol. A 17(6) (1999) 3505.
18. "Finding a pump just got easier", R&D Magazine, Feb. 2000. Note: table describing and comparing the pumps from 40 different suppliers.
19. Youfan Gu, "Managing TEOS Effluents", R&D Magazine, Feb. 2000, p. 67.
20. John Freeman, "Cost Down and performance up!", Inside Vacuum, Pfeiffer's Customer Magazine, no. 5. Winter 2000. p. 9. A short article describing Balzer's Split Flow Turbo Pumps. (Pfeiffer Vacuum is located in Nashua, NH)
21. Vic. Comello, "Turbos Designed for Harsh Environments", R&D Magazine, March 2000, p. 45.
22. Phillip A. Lessard, "Vacuum Pumping Systems for Chemical Vapor Deposition Tools", Vacuum Technology & Coating, June 2000, p. 34.
23. J. J. Manura, "Vacuum Pump Exhaust Filters. Part I: A Two Stage Vacuum Pump Exhaust Filter System", The Mass Spec Source, Summer 2000, p. 4. Note: A newsletter published by Scientific Instrument Services, Inc. Ringoes, NJ. [www.sisweb.com](http://www.sisweb.com).
24. Peter M. Yau and Atul N. Patil, "Chemical Scroll Pumps Are Ideal for Lab Applications", R&D Magazine, June 2000, p. 80
25. Vic Comello, "Roots Pumps are Versatile Performers", R&D Magazine, Back to Basics, June 2000, p. 93.
26. Vic Comello, "High Speed Screw Pumps Being Developed for 300-mm Wafers", R&D Magazine, May 2000, p. 73.
27. Philip Lessard, "Dry Vacuum pumps for semiconductor processes: Guidelines for primary pump selection", JVST A 18(4) (2000) 1777.
28. R. P. Davis et. al. "Dry Vacuum pumps: A method for the evaluation of the degree of dry", JVST A 18(4) (2000) 1782.

29. Atul Patil, "Improving High Vacuum Pumping Performance Using a Cryogenic Water Pump Backed by a Turbomolecular Pump", July 2000, Vacuum Technology & Coating, p. 40.
30. Vic Comello, "Ion Pumps Provide Clean UHV Environments", R&D Magazine, July 2000, p. 45
31. Steven Chambreau, et. al. , "Low cost, mechanically refrigerated diffusion pump baffle for ultrahigh vacuum chambers", J. Vac. Sci. Technol. A 18(5) (2000) 2581
32. Kimo Welch, "Closed-Loop Gaseous Helium Cryopumps", Vacuum Technology and Coating, Spetember 2000, p. 8
33. M. H. Hablanian, "The Hybrid High Vacuum Turbopump", Vacuum Technology and Coating, Sept 2000, p. 40.
34. Heinz Barfus, et.al. , "Moving Dry Pumps From the Subfab Floor To the Tool", R&D Magazine, September 2000, S18.
35. Kimo Welch, "The Cryopump Placebo Effect", Vacuum Technology and Coating, September 2000, p. 10.
36. "Alloys Update Getter Pumps", R&D Magazine, November 2000.
37. Phil Danielson, "Diaphragm Pump Designs Determine Results", R&D Magazine, November 2000.
38. Phil Danielson, "How to Match Pumping Speed to Gas Load", R&D Magazine, December 2000, p. 30.
39. Phil Danielson, "Careful Consideration Means getting the right pump", R&D Magazine, April 2001, p. 29.
40. Donald Mattox, "Mechanical Vacuum Pumps", Vacuum Technology &Coating, April 2001, p. 53.
41. Dale Morton, "The effects of Pumping Speed on the Operation of a Cold Cathode Ion Source", Vacuum Technology and Coating, June 2001, p. 36.
42. Phil Danielson, "Making the Oil-Sealed vs. Oil Free Decision", R&D Magazine, July 2001, p. 66.
43. A. Liepert and P. Lessard, "Design and operation of scroll-type dry primary vacuum pumps", J. Vac. Sci. Technol. A19(4) (2001) 1708
44. Donald Mattox, "Oil Diffusion Pumps", Vacuum Technology and Coating, July 2001. P.26
45. P.D. Vibert, "Troubleshooting Vacuum Pumping Systems", Vacuum Technology and Coating, July 2001, p. 55.

46. C. G. Masi, "Instrumentation Needs Drive Turbopump Development", R&D Magazine, Oct 2001, p. 16
47. Phil Danielson, "Matching Vacuum Pump to process", R&D Magazine, November 2001, p. 53. Note: A quick , concise and useful primer on pump choices.
48. Phil Danielson, "Water Vapor Pumping Produces Unique Problems", R&D Magazine Feb 2002, p.59.
49. Bob Langley et. al., "Picking the right pump and the Sizing and matching of Pumps", Vacuum Technology and Coating, May 2002, p.23.
50. Terrence Thompson, "Roughing Pumps, Dry and Oil Filled", Vacuum Technology and Coating, November 2002, p. 42.
51. Terrence Thompson, "High-Vacuum Pumps", Vacuum Technology and Coating, Dec 2002, p.52. Note: An up-to date compilation of HV pump technologies and manufacturers.
52. Jurgen Breitenbach, "The Influence of Diaphragm Pumps on the Hydrogen Partial Pressure in High Vacuum Systems", Vacuum Technology and Coating, Jan. 2003, p.38.
53. Donald Mattox, "Turbomolecular Vacuum Pumps", Vacuum Technology and Coating, Jan 2003, p.24.
54. Ron Hawranko, "How to Choose a TurboPump", R&D Magazine, July 2003, p. 46

## **Total Pressure Measurement**

1. J. H. Leck, "Total and Partial Pressure Measurement in Vacuum Systems", edited by Blackie and Son Limited, 1989, Glasgow and London,.
2. Stephen P. Hansen, Vacuum and Thin Film, May 1999, p. 24, "Vacuum Pressure Measurement".
3. P.A. Redhead, J. Vac. Sci. Technol. A12(4) (1994) 904, "History of Ultrahigh Vacuum Pressure Measurements".
4. P. A. Redhead, Vacuum 44 (1993) 559, "UHV and XHV Pressure Measurement".
5. Tilford, C., JVST A1(2) (1983) 152, "Reliability of high vacuum measurements".
6. W. A. Levinson, Semiconductor International, Oct. 1995, p. 165, "How Good is your gauge?".
7. Dick Jacobs, Vacuum&ThinFilm, February 1999, p. 30, "Advances in Capacitance Manometers for Pressure Measurement"

8. Tim Studt, "Reliability, Cost and Size Demands Dominate New Gauge Designs", R&D Magazine, Vacuum Technology Section, May 1996, p. 54.
9. John Sullivan, "Advances in Vacuum Measurement Almost Mette Past Projections", R&D Magazine, August 1995, p. 31.
10. Peter Singer, "Trends in Vacuum Gauging", Semiconductor International, March 1992, p. 78.
11. B. R. Kendall et. al. , J. Vac. Sci. Technol. A15(3) (1997) 740, "Cold Cathode Gauges for ultrahigh vacuum measurements".
12. Stephen Hansen and Kathryn Whitenack, "Pressure measurement and control in loadlocks", Solid State Technology, October 1997, p. 151.
13. Eric Bopp, "Pressure measurement in ion implanters", Solid State Technology, Feb. 2000, p. 51. Note: Includes a comparison between cold and hot cathode gauge performance in ion implant applications.
14. B. R. F. Kendall and E. Drubetsky, "Compact wide range cold cathode gauges", JVST A18(4) (2000) 1724.
15. C. P. Grudzien and D. J. Lischer, "New Enhanced Performance low pressure Capacitance Manometer", JVST A 18(4) (2000) 1730.
16. James Lee, " The future of Web-Enabled Vacuum Instrumentation", R&D Magazine, Oct. 2000, p. 29.
17. Fiona Redgrave, "How to choose a vacuum gauge", Vacuum Solutions, November/December 2000, p.50.
18. Emil Drubetsky and Richard Glazewski, "Vacuum Measurements using Modern Cold Cathode Technology", Vacuum Technology and Coating, Oct 2002, p. 54.
19. Donald Mattox, "Vacuum Gauging", Vacuum Technology & Coating, February 2003, p. 26.
20. Donald Mattox, "Vacuum Gauges for the Plasma Environment", Vacuum Technology and Coating, June 2003, p. 26 . Note: Capacitance Manometers and Spinning Rotor Gauges are discussed as preferred gauges for PVD applications where plasmas can interfere with ionization sources.

## Bayard-Alpert Ionization Gauges

1. D. Alpert, Journal of Applied Physics 24 (1953) 860, "New Developments in the production and measurement of UHV". **Note:** *This is the report on the invention of the B-A Gauge*
2. J. H. Singleton, "Practical guide to the use of Bayard-Alpert Ionization Gauges", J. Vac. Sci. Technol. A19(4) (2001)1712.

3. Gerardo Brucker, "Which Bayard-Alpert Gauge is best for you?", R&D Magazine, Feb. 2000, p. 69.
4. Peter Nash, "The use of hot filament ionization gauges", Vacuum 37 (1987) 643
5. P. E. Gear, "The choice of cathode material in a hot cathode ionization gauge", Vacuum 26(1) (1975) 3
6. George Comsa, "Ion Collection in Bayard-Alpert Gauges", J. Vac. Sci. Technol. 9 (1971) 117. *Note: Great paper on how it all works inside the gauge.*
7. P. A. Redhead, JVST 6 (1969) 848, "The sensitivity of Bayard-Alpert Gauges".
8. Tilford, Charles, JVST A3(3) (1985) 546, "Sensitivity of hot cathode ionization gauges". **Note:** Very useful information on gauge-to-gauge reproducibility of commercial B-A gauge sensitivities.
9. T.A. Flaim and P.D. Ownby, J. Vac. Sci. Technol. 8(5) (1971) p 661, "Observations on B-A Ion Gauge Sensitivities To Various Gases"
10. Albert Filippelli et. al., "Search for pressure dependence in the sensitivity of several common types of hot-cathode ionization gauges for total pressures down to  $10^7$  Pa", J. Vac. Sci. Technol. A9(5) (1991) 2757
11. Abbott, P.J. et. al. JVST A12(5) (1994) 2911, "Influence of the filament potential wave form on the sensitivity of glass envelope B-A gauges".
12. Filippelli AS. R., JVST A14(5) (1996) 2953, "Influence of envelope geometry on the sensitivity of "nude" ionization gauges"
13. Suginuma S. et. al. , "Dependence of sensitivity coefficient of a nude type Bayard-Alpert Gauge on the diameter of an envelope", Vacuum 53 (1999) 177-180.
14. Charles Morrison, "Safety Hazard from gas discharge interactions with the Bayard-alpert ionization gauge", J. Vac. Sci. Technol. A 3(5) (1985) 2032
15. N. T. Peacock, "Measurement of x-ray currents in Bayard-Alpert type gauges", J. Vac. Sci. Technol. A 10(4) (1992) 2674
16. B. R. F. Kendall, "Ionization gauge errors at low pressures", J. Vac. Sci. Technol. A17(4) (1999) 2041
17. B. R. F. Kendall and E. Drubetsky, "Stable Cancellation of x-ray errors in B-A gauges", J. Vac. Sci. Technol A 16(3) (1998) 1163
18. Tilford, C. ,JVST A13(2) (1995) 485, "Comments on the stability of Bayard-Alpert ionization Gauges". **Note:** Great information on the long-term stability of commercial B-A gauge sensitivities. Useful recommendations on gauge operation.

19. R. N. Peacock and N. T. Peacock, "Sensitivity variation of Bayard-Alpert Gauges with and without closed grids from  $10^{-4}$  to 1 Pa", J. Vac. Sci. Technol. A(8) (1990) 3341
20. Bills, D. G., JVST A12(2) (1994) 574, "Causes of nonstability and nonreproducibility in widely used Bayard-Alpert ionization gauges".
21. S. D. Woods and C. R. Tilford, "Long-term stability of two types of hot cathode ionization gauges", J. Vac. Sci. Technol. A3 (3) (1985) 542
22. P. C. Arnold et. al. "Non-stable behavior of widely used ionization gauges", J. Vac. Sci. Technol. A 12(2) (1994) 568
23. Tilford, C. et. al. , JVST 20 (1982) 1140, "Performance characteristics of a broad range ionization gauge tube".
24. K. Jousten and P. Rohl, "Instability of the spatial electron current distribution in hot cathode ionization gauges as a source of sensitivity changes", J. Vac. Sci. Technol. A 13(4) (1995) 2266
25. Arnold, P. C. et. al. ,JVST A12(2) (1994) 580, "Stable and reproducible Bayard-Alpert ionization gauge".(Note: The birth of Granville Phillip's Stabil-Ion Gauge)
26. Siska, P. E. Rev. Sci. Instrum. 68(4) (1997) 1902, "Partial Rejuvenation of B-A ionization gauge tubes".
27. Cox. M. C. et. al., JVST A14(5) (1996) 2963 , "Filament Replacement for nude Bayard Alpert Ionization gauges".
28. R. Baptist et. al. , "Bayard-Alpert vacuum Gauge with microtips" J. Vac. Sci. Technol. B14(3) (1996) 2119
29. Peacock, R. N. et. al. , JVST A9(3) (1991) 1977, "Comparison of hot cathode and cold cathode ionization gauges".
30. Beeck, U. et. al. , JVST 9 (1971) 126 , "Comparison of the pressure indication of a Bayard-Alpert and an Extractor Gauge".
31. H. Akimichi, K. Takeuchi, and Y. Tuzi and I. Arakawa, "Long term behavior of an axial-symmetric transmission gauge", J. Vac. Sci. Technol. A17 (1999) 2021.
32. Vic Comello, R&D Magazine, May 1999, p. 57, "Simplify Rough Pumping With a Wide Range Gauge"
33. H. Saeki and T. Momose, "Vacuum gauge self-compensating external environment in the Spring-8 storage ring", J. Vac. Sci. Technol. A 18(1) (2000) 244
34. Edelmann, Chr.; Iwert, Th.; Kauert, R.; Knapp, W., " Some studies of the axial emission ionization gauge according to Chen and Suen", Journal of the Vacuum Society of Japan 37 (1994) 9, 686-691

35. Kieler, O.F.O.; Biehl, St.; Kauert, R.; Knapp, W., Edelmann, Chr. “Theoretical and experimental desorption investigations at ionization gauges”, Vacuum, Vol. 47 (1996), No. 4, 351-355
36. Edelmann, Chr.; Kauert, R.; Kieler, O.F.O., “On some Improvements of Ionization Gauges of the extractor Type for the Measurement of Extreme High Vacuum”, Journal of Vacuum Society of Japan Vol. 39, No. 4 (1996), 149-158
37. Kauert, R.; Kieler, O F O; Biehl, St; Knapp, W, Edelmann, Chr., Wilfert, St. “ Numerical investigations of hot cathode ionization gauges”, Vacuum 51 (1998) 53
38. R. Kauert, S. Wilfert, C. Edelmann, “Bayard-Alpert gauge with additional ion collector for pressure measurements from  $10^{-9}$ - $10^1$  mbar”, Vacuum 57(3) (2000) 283-293.
39. Gerardo Brucker, “Improvements Coming in Ion Gauge Controllers”, R&D Magazine, July 2000, p.41. Note: Use this article as a guide when trying to choose a new ion gauge controller for your vacuum lab.
40. R&D Magazine, “Gauge Controller Has Many Unexpected Features”, August 2000, p. 45. **Note:** R&D Magazine product exclusive describing the features of the IGC100 controller.
41. Miertusova J. , “Reliability and accuracy of total and partial pressure measurements in the UHV pressure range under real experimental conditions” , Vacuum 51 (1998) 61.
42. U. Beech and G. Reich, “Comparison of the Pressure Indication of a Bayard-Alpert and an Extractor Gauge”, J. Vac. Sci. Technol. 9(1) (1971) 126.
43. Hiroshi Saeki, “Vacuum Gauge system with a self-compensator for photoelectrons produced in the Spring-8 storage ring”, J. Vac. Sci. Technol. A 19(1) (2001) 349
44. P. H. LaMarche, et. al.,”Neutral Pressure and gas flow instrumentation for TFTR”, Rev. Sci. Instrum. 56(5) (1985) 981. Note: there is an excellent description of an Ion Gauge setup allowing Bayard-Alpert Gauge measurements in the presence of magnetic fields.

## **Pirani/Thermocouple Gauges**

1. J. English et. al. J. Sci. Instrum. 42 (1965) 77, “A wide Range constant resistance Pirani Gauge with ambient temperature compensation”.
2. Heijne,L. et. al. , Philips Technical Review, 30(1969) 166, “A Pirani Gauge for pressures up to 1000 Torr and higher”.
3. K. F. Poulter et. al. , J. Vac. Sci. and Technol. 17(2) (1980) 638, “Reproducibility of the performance of Pirani Gauges”.

4. Vic Comello, "When to Choose a Thermocouple Gauge", R&D Magazine, May 2000, p. 75.
5. T. M. Berlicki, "Heat Dissipation in thin-film vacuum sensor", J. Vac. Sci. Technol. A 19(1) (2001) 325.
6. E. Zakar et. al. , "Process and fabrication of lead zirconate titanate thin film pressure sensor", J. Vac. Sci. Technol. A 19(1) (2001) 345.
7. S. N. Wang, "Thermal Micropressure sensor for pressure monitoring in a minute package", J. Vac. Sci. Technol. A 19(1) (2001) 353
8. Suman Chatterjee, et. al. , "A Vacuum gauge using positive temperature coefficient thermistor as the sensor", Rev. Sci. Instr., 71(2000) 4670.

## Pressure Calibration/Spinning Rotor Gauge

1. W. Steckelmacher, Vacuum 37 (1987) 651, "The Calibration of Vacuum Gauges".
2. Sharrill Dittmann, "High Vacuum Standard and its use", NIST Special Publication 250-34. U.S. Department of Commerce , National Institute of Standards and Technology,
3. K. E. McCulloh et. al. "Summary Abstract: The national Bureau of standards orifice-flow primary high vacuum standard", J. Vac. Sci. Technol. A4(3) (1986) 362
4. Tilford, C. et. al. , JVST A6(5) (1988) 2853, "The National Bureau of Standards primary high-vacuum standard".
5. K. E. McCulloh et. al. "Low-range flow-meters for use with vacuum and leak standards", J. Vac. Sci. Technol. A5(3) (1987) 376
6. P. D. Levine et. al. JVST A14(3) (1996) 1297, "A primary high vacuum calibration station for industrial applications".
7. P. D. Levine et. al. "Development of a primary standard UHV calibration station", J. Vac. Sci. Technol. A 12(4) (1994) 1727
8. P. D. Levine et. al. "Precision gas flowmeter for Vacuum calibration", J. Vac. Sci. Technol. A 15(3) (1997) 747
9. J. K. Fremerey, J. Vac. Sci. Technol. A3 (3) (1985) 1715, "The Spinning Rotor Gauge".
10. J. Setina, "Two Point calibration scheme for the linearization of the spinning rotor gauge at transition regime pressures", J. Vac. Sci. Technol. A 17(4) (1999) 2086
11. Sharrill Dittmann et. al. , "The Molecular drag gauge as a calibration Standard", J. Vac. Sci. Technol. A7(6) (1989) 3356

12. K. Jousten, A.R. Filippelli, C.R. Tilford, and F. J. Redgrave, "Comparison of the standards for high and ultrahigh vacuum at three national standards laboratories", J. Vac. Sci. Technol. A 15 (4) (1997) 2395
13. J. P. Looney et. al. "PC Based spinning rotor gage controller", Rev. Sci. Instr. 65(9) (1994) 3012
14. James Basford et. al. "Recommended practice for the calibration of Mass spectrometers for partial pressure analysis", J. Vac. Sci. Technol. A 11(3) (1993) A22
15. P. Mohan "Vacuum Gauge calibration at the NPL (India) using orifice flow method" Vacuum 51(1998) 69
16. R. E. Ellefson, A. P. Miller, "Recommended practice for calibrating vacuum gauges of the thermal conductivity type", J. Vac. Sci. Technol. A 18(5) (2000) 2568-2577.
17. Kimo M. Welch, "A Poor-Man's Traceable High Vacuum Gauge Calibration System", Vacuum Technology and Coating, Nov/Dec 2000, p. 8. Note: This is a great article on how to make a simple calibration station for HV Gauge calibration.
18. S. P. Hansen, "Vacuum Instrument Calibration & Personnel Training Boost Productivity", Vacuum Technology & Coating, April 2001, p. 46.
19. Kimo Welch, "Verifying a Leak Checker's Sensitivity to  $10^{-12}$  TorrL/s (He)", Vacuum Technology & Coating, April 2001, p.12.

## Temperature Programmed Desorption

1. P.A. Redhead, Vacuum, 12 (1962) 203, "Thermal Desorption of Gases". Note: A "Classic" paper with the basics.
2. J. T. Yates, Jr. et. al. , Surface Science 322 (1995) 243, "CO adsorption on stepped Pd (112): studies by thermal and electron stimulated desorption". **Note:** Read anything by Yates.
3. J. T. Yates, Methods in Experimental Physics, vol. 22 , Academic Press Orlando 1985, p. 425.
4. John T. Yates, "Experimental Innovations in Surface Science. A guide to Practical Laboratory Methods and Instruments", Springer-Verlag, New York, 1997. **Note:** Everything starting at page 366 and above is essential information.
5. J. L. Gland, et. al. J. Phys. Chem. 100 (1996) 11389, "Temperature Programmed Desorption Spectra of Systems with Concentration Gradients in the Solid Lattice"
6. J. L. Gland, et. al. Surface Science 355 (1996) L385, "The effects of exposure time and pressure on the TPD spectra of systems with bulk states"

7. A. M. de Jong et. al. "Thermal Desorption Analysis: Comparative test of ten commonly applied procedures", Surface Science 233 (1990) 355. **Note:** You must get this paper if you do not have it yet!
8. J. Gunster et. al., "Mg clusters on MgO surfaces: Characterization with metastable impact electron spectroscopy, ultraviolet photoelectron spectroscopy and temperature programmed desorption, A 17(4) (1999) 1657
9. V. A. Bondzie, S. C. Parker and C. T. Campbell, "Oxygen Adsorption on well defined gold particles on TiO<sub>2</sub> (110), J. Vac. Sci. Technol. A 17 (4) (1999) 1717
10. Li Chen and Jeff Kelber, "Polymerized C-Si films on metal substrates: Cu adhesion/diffusion barriers for ultralarge scale integration?, J. Vac. Sci. Technol. A17(4) (1999) 1968
11. J. W. Niemantsverdriet et. al. "The compensation effect in thermal desorption of adsorbate systems with lateral interactions", J. Vac. Sci. Technol. A 6 (3) (1998) 757
12. J. W. Niemantsverdriet et. al., "Thermal desorption of strained monoatomic Ag and Au layers from Ru(001)", J. Vac. Sci. Technol. A 5(4) (1987) 875
13. R. M. Hardeveld et. al. "The adsorption of NH<sub>3</sub> on Rh(111)", Surface Science 369(1996) 23-35
14. R. M. Hardeveld et. al."Kinetics of elementary surface reactions studied by static secondary ion mass spectrometry and temperature programmed reaction spectroscopy", J. Mol. Catalysis A: Chem 131 (1998) 199-208
15. Herbert J. Tobias and Paul J. Ziemann, "Compound Identification in Organic Aerosols Using TPD Particle Beam Mass Spectrometry", Anal Chem. 71 (1999) 3428-3435
16. D. Schleussner, et. al. "Temperature Programmed Desorption from Graphite", J. Vac. Sci. Technol. A17(5) (1999) 2785
17. St. J. Dixon-Warren, et. al. "Butanethiol on Au{100}-(5X20) using a simple retractable doser", J. Vac. Sci. Technol. A17(5) (1999) 2982. **Note:** Uses two **SRS RGA's** for TPD measurements in an UHV setup.
18. K. W. Bryant et. al. , "Versatile and economic specimen heater for ultrahigh vacuum applications", J. Vac. Sci. Technol. A17(5) (1999) 3057
19. St. J. Dixon-Warren, N. Burson, V. Bondzie, L. Zhang, Y. Yu, L. Lucchesi, "A Simple Single Crystal Sample Temperature Controller Based on Commercial Components for UHV Surface Science Application", Rev. Sci. Instr., 69 (1998) 3006
20. M. J. Weiss, C. J. Hagedorn, and W. H. Weinberg, "Observation of gas-phase atomic oxygen with Ru(001)-p(1x1)-D at 80K, J. Vac. Sci. Technol. A 16(6) (1998) 3521. **Note:** an **SRS RGA200** is used to collect the TPD data.

21. Babu R. Chalamala, David Uebelhoer and Robert H. Reuss, "Apparatus for temperature programmed desorption studies of thin films", Rev. Sci. Instr. 71 (2000) 320. **Note:** Uses **SRS RGA300** in the TPD setup.
22. C. G. Wiegenstein et. al. , "A virtual approach for automation of temperature programmed desorption", Rev. Sci. Instrum., 69(10) (1998) 3707.
23. Tyler Watt and Nicholas Materer, "Temperature programmer for surface science studies with application to semiconductor surfaces", J. Vac. Sci. Technol. A20(2) (2002) 572.
24. Sung-II Cho, "TPD Study on the decomposition mechanism of  $Ti(OC_3H_7)_4$  on Si(100)", J. Electrochem. Soc. 148(9) (2001) C599

## **Membrane Introduction Mass Spectrometry (MIMS)**

1. R. T. Short et. al. , "Underwater Mass Spectrometers for in situ Chemical analysis of the Hydrosphere", J. Am. Soc. Mass Spectrom. 12 (2001) 676. **Note:** An RGA is used in combination with Membrane Introduction Mass Spectrometry (MIMS) to do underwater analysis of VOCs.
2. Colin S. Creaser, David Gomez Lamarca, Jeffrey Brum, Christopher Werner, Anthony P. New and Luisa M. Freitas dos Santos, "Reversed-Phase Membrane Inlet Mass Spectrometry Applied to the Real-Time Monitoring of Low Molecular Weight Alcohols in Chloroform", Anal. Chem. 74(2002) 300-304. **NOTE:** A **SRS QMS300** is used to perform real-time MIMS determinations of alcohols in chloroform. RGAs are rapidly gaining acceptance in this field as their excellent price/performance value is realized by MIMS practitioners.
3. Raimo Ketola, et. al., "Environmental applications of MIMS", Journal of Mass Spectrometry 37 (2002) 457. **Note:** Excellent review article with tons of references and a list of published experiments sorted by analyte type and technique.

## **Variable Leak Valves**

1. Robert A. Langley and Paul LaMarche, "Variable Valves/Leaks", Vacuum Technology & Coating, April 2003, p.24.
2. R. A. Langley, et.al., "Gas injection system for the Advanced Toroidal Facility", JVST A7 (1989) 2423. **Note:** An elastomer seal, with piezoelectric actuator valve is described.
3. R. A. Langley et.al. , "A calibrated Variable Leak for use in ion Source Operation", JVST A19 (2001) 673. **Note:** a pinched tube valve, compatible with H Voltage operation, is described.

---

## Vacuum and Process Control Publications

1. **The Journal of Vacuum Science & Technology A.** Vacuum, Surfaces and Films. Published six times annually by the American Vacuum Society ([www.vacuum.org](http://www.vacuum.org)). A consistently good refereed journal with lots of papers on vacuum technology subjects. Available on-line: <http://ojps.aip.org/jvsta/>.
2. **The Journal of Vacuum Science & Technology B.** Microelectronics and Nanometer Structures. Published six times annually by the American Vacuum Society ([www.vacuum.org](http://www.vacuum.org)). A consistently good journal with lots of refereed papers on semiconductor processing issues. Available on-line: <http://ojps.aip.org/jvstb/>
3. **Vacuum.** The international journal Vacuum publishes high quality papers on latest advances in the many areas which now require the production and control of a working environment at pressure below one atmosphere. Published by Pergamon Press, a division of Elsevier Books and Journals: [www.elsevier.nl](http://www.elsevier.nl).
4. **Review of Scientific Instruments.** A monthly journal from the American Institute of Physics ([www.aip.org](http://www.aip.org)) devoted to scientific instruments, apparatus and techniques. Available on-line: <http://ojps.aip.org/rsio/>. Always a very fun journal to read. A must-read for instrument designers and experimental scientists trying to stay up-to-date.
5. **Vacuum Technology & Coating.** A new magazine that started on JAN 2000. For subscriptions contact [www.vactechmag.com](http://www.vactechmag.com). Loaded with vacuum information, high on editorial, low on ads.
6. **Semiconductor International.** Another monthly Cahners publication dedicated to semiconductor processing subjects. Available on the web: [www.semiconductor.net](http://www.semiconductor.net)
7. **Solid State Technology.** A monthly PennWell publication, available on-line: [www.solid-state.com](http://www.solid-state.com)
8. **Micro.** A monthly Cannon Communications Publication that often deals with vacuum contamination issues. Available on-line: [www.micromagazine.com](http://www.micromagazine.com). They have a deep article archive in their website where you can find most of the MICRO papers referenced here.
9. **FUTURE FAB International.** Published by Technology Publishing, Ltd. in the U. K., e-mail: [tech@techpub.org](mailto:tech@techpub.org).
10. **AVS Monograph Series.** The American Vacuum Society (AVS, [www.vacuum.org](http://www.vacuum.org)) publishes a whole series of monographs on vacuum technology and processing subjects. They are all very good and worth checking out. Some of the books are required minimum reading for vacuum practitioners.

## Vacuum and Process Control Websites

1. [www.vacuumblog.com](http://www.vacuumblog.com): An on-line “Journal of Useful and Practical Vacuum Technology”, published on-line by Phil Danielson. No advertisements, no product selling, just plain old vacuum knowledge. We highly recommend it. It even includes an “Ask Phil” section where you can submit any of those vacuum questions that have puzzled you in the past. We encourage you to challenge Phil! At this point the website is completely free and open to the general public.
2. [www.thinkSRS.com](http://www.thinkSRS.com): The SRS website is packed with very useful application notes related to vacuum applications and instrumentation. Check it out! We are constantly adding new notes to our list of applications.

Last update: 9/26/2003