AH Capacitance/Loss Bridges are used in diverse research fields. This list references selected publications describing research in which AH bridges have been used. The references have been sorted into the following categories:

1. **DIELECTRIC CHARACTERIZATION**
2. **CARBON NANOTUBES, NANOWIRES, QUANTUM DOTS**
3. **DILATOMETRY - (INCLUDES: THERMAL EXPANSION, MAGNETOSTRICTION)**
4. **FERROELECTRICS**
5. **BIOPHYSICS**
6. **LIQUID CRYSTALS**
7. **LOW TEMPERATURE PHYSICS**
8. **MAGNETOCAPACITANCE / MAGNETORESISTANCE / MAGNETODIELECTRIC EFFECT**
9. **MAGNETOMETRY**
10. **PRESSURE / CAPACITIVE BOLOMETRY**
11. **SCANNING CAPACITANCE MICROSCOPY (SCM) / SPECTROSCOPY**
12. **SINGLE ELECTRON TUNNELING (SET)**
13. **STRUCTURE AND PHASE TRANSITIONS**
14. **SUPERCONDUCTIVITY**
15. **SUPERFLUIDS**
16. **TUNNELING**
17. **ATOMIC LAYER DEPOSITION (ALD)**
18. **NANO-FORCE METROLOGY**
19. **PRECISION POSITIONING**
20. **SCANNING TUNNELING MICROSCOPY (STM)**
21. **GLASSES**
22. **GRAVITY**
23. **SEMICONDUCTOR TEST**
24. **ELECTRICAL/CAPACITANCE METROLOGY**
25. **MISCELLEANOUS**

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Selected Publications discussing applications of Andeen-Hagerling Capacitance Bridges and AH1100/AH11A Fused-Silica Standards and Frame along with some side-notes

As of September 2010

1. DIELECTRIC CHARACTERIZATION

"Accurate Determination of the Audio Frequency Dielectric Properties of a-Quartz and Vitreous Silica", Carl Andeen and Donald Schuele, Case Western Reserve University, and Thomas C. Brasco and John Fontanella, U.S. Naval Academy; **1975 Annual Report of the Conference on Electrical Insulation and Dielectric Phenomena**. Based on the paper presented at the 44th Annual Meeting of the Conference, National Institute of Standards and Technology (NIST), Gaithersburg, Maryland, November 3-6, 1975.

"Effect of OH on The Low-Frequency Dielectric Constant of Vitreous Silica", Carl Andeen and Donald Schuele, Case Western Reserve University, and John Fontanella, U.S. Naval Academy; **Journal of Applied Physics**, Volume 45, Issue 3, March 1974, pp. 1071-1074.

"The Dielectric Properties of As-Received and Gamma Irradiated Fused Silica", John Fontanella and Richard L. Johnston, U.S. Naval Academy, and George H. Sigel, Jr., Naval Research Laboratory, and Carl Andeen, Case Western Reserve University; **Journal of Non-Crystalline Solids,** Volume 31, Issue 3, April 1979, pp. 401-414.

Chad R. Snyder and Frederick I. Mopsik worked with E. K. Lin, W. E. Wallace, and W. L. Wu, (all at National Institute of Standards and Technology (NIST)) and C. X. Zhang and R. M. Laine with the University of Michigan, to author, **"Characterization of Epoxy-Functionalized Silsesquioxanes As Potential Underfill Encapsulants", (Materials Research Society Procedures**, San Francisco, California, Volume 519, 1998, pp. 15-20), again using a novel capacitance cell.

Dielectric properties of porous glass, (see **"Modification of Dielectric Properties of Porous Glass By Adsorption of Hydrogen"**, A. Dertinger, M. Schindler, Y. Kondo, F. Pobell, **Physical Review B**, Volume 55, Issue 22, June 1, 1997, pp. 14689-14692). Vycor glass was used as the dielectric between two copper disks with the **AH2500A** measuring the changes made at 1 kHz during the experiment. At the time, the **AH2700A** multi-frequency bridge was not available, and another instrument was used to measure at various frequencies.

John Graham, Marek Kryzeminski, and Zoran Popovic, used an **AH2500A** to accurately measure a known capacitor against an unknown capacitive film in their **"Capacitance Based Scanner For Thickness Mapping of Thin Dielectric Films"**, **Review of Scientific Instruments**, Volume 71, Issue 5, May 2000, pp. 2219-2223. They note that the speed of the **AH2500A** is not sufficient for fast scans and these might take several hours to complete with the bridge. [Author's note: It may be that the **AH2700A** multi-frequency bridge (50 Hz to 20 kHz, with its 3 kHz analog output (down 3db) might improve this condition.]

Several early articles were co-authored by Dr. Carl Andeen and relate to the use of the **AH2xx0** series of capacitance/loss bridges. These are **"Low-Frequency Dielectric Constant of LiF, NaF, NaCl, NaBr, KCl, and KBr**

by the Method of Substitution", Carl Andeen, John Fontanella, Donald Schuele; **Physical Review B**, Volume 2, Issue 12, December 15, 1970, pp. 5068-5073 and

"Accurate Determination of the Dielectric Constant by the Method of Substitution", Carl Andeen, John Fontanella, Donald Schuele; **Review of Scientific Instruments**, Volume 41, Issue 11, November 1970, pp. 1573-1576.

"Solubility of Solids In Supercritical Fluids From The Measurements of The Dielectric Constant: Application To CO_2 - Naphthalene", A. Hourri, J. M. St-Arnaud, T. K. Bose; **Review of Scientific Instruments**, Volume 69, Issue 2, July 1998, pp. 2732-2737.

"Dielectric and Ellipsometric Studies of The Dynamics In Thin Films of Isotactic Poly (Methylmethacrylate) With One Free Surface", J. S. Sharp, J. A. Forrest; **Physical Review E**, Volume 67, Issue 3, March 2003, p. 031805.

"The Dielectric Response of Chloromethylsilyl and Dichloromethylsilyl Dipolar Rotors on Fused Silica Surfaces", Laura I. Clarke, Dominik Horinek, Gregg S. Kottas, Natalia Varaksa, Thomas F. Magnera, Tanja P. Hinderer, Robert D. Horansky, Josef Michl, John C. Price; **Nanotechnology**, Volume 13, Number 4, August 2002, pp. 533-540.

"Toroidal Cross Capacitor For Measuring the Dielectric Constant of Gases", Thomas J. Buckley, Jean Hamelin, M. R. Moldover; **Review of Scientific Instruments**, Volume 71, Issue 7, July 2000, pp. 2914-2921.

"A.C. Dielectric and TSC Studies of Constrained Amorphous Motions in Flexible Polymers Including Poly (oxymethylene) and Miscible Blends", Bryan B. Sauer, Peter Avakian, Edmund A. Flexman, Mimi Keating, Benjamin S. Hsiao, Ravi K. Verma; **Journal of Polymer Science Part B: Polymer Physics**, Volume 35, Issue 13, December 7, 1998, pp. 2121-2132.

"High-Accuracy Data for the Metering of the Heating Value of Natural Gas via In-Pipeline Measurements", M. Moldover, T. J. Buckley; **NIST**, 2002.

"Evolution of the Dynamics in 1,4-Polyisoprene from a Nearly Constant Loss to a Johari-Goldstein β-Relaxation to the α-Relaxation", C. M. Roland, M. J. Schroeder, J. J. Fontanella, K. L. Ngai; **Macromolecules**, Volume 37, Number 7, April 6, 2004, pp. 2630-2635.

"Reference Values of the Dielectric Constant of Natural Gas Components Determined with a Cross Capacitor", M. R. Moldover and T. J. Buckley; **International Journal of Thermophysics**, Volume 22, Number 3, May 2001, pp. 859-885.

"Magnetic Field Effect and Dielectric Anomalies at the Spin Reorientation Phase Transition of $GdFe_3 (BO_3)_4$", F. Yen, B. Lorenz, Y. Y. Sun, C. W. Chu, L. N. Bezmaternykh, A. N. Vasiliev; **Physical Review B**, Volume 73, Issue 5, February 2006, p. 054435.

"Low Temperature Dielectric Anomalies in $HoMnO_3$: The Complex Phase Diagram", F. Yen, C. R. dela Cruz, B. Lorenz, Y. Y. Sun, Y. Q. Wang, M. M. Gospodinov, C. W. Chu; **Physical Review B**, Volume 71, Issue 18, May 2005, p. 180407.

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"New Dielectric Material For Low Temperature Thermometry In High Magnetic Fields", M. M. Maior, S. B. Molnar, Yu M. Vysochanskii, M. I. Gurzan, P. H. M. van Loosdrecht, P. J. E. M. van der Linden, H. van Kempen; **Applied Physics Letters**, Volume 62, Issue 21, May 24, 1993, pp. 2646-2648.

"A New Multiferroic Material: $MnWO_4$", O. Heyer, N. Hollmann, I. Klassen, S. Jodlauk, L. Bohaty, P. Becker, J. A.

Mydosh, T. Lorenz, D. Khomskii; **Journal of Physics: Condensed Matter**, Volume 18, Number 39, October 4, 2006, pp. L471-L475.

"Amorphous Dielectric Behavior of Incommensurate Ferroelectric $(Pb_{0.45}Sn_{0.55})_2P_2Se_6$ at Low Temperatures", M. M. Maior, S. A. J. Wiegers, F. C. Penning, H. van Kempen, J. C. Maan; **Physical Review B**, Volume 55, Issue 6, February 1, 1997, pp. 3507-3511.

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"Magnetic Phase Diagrams of The Kagome Staircase Compound $Co_3V_2O_8$", F. Yen, R. P. Chaudhury, E. Galstyan, B. Lorenz, Y. Q. Wang, Y. Y. Sun, C. W. Chu; **Physica B: Condensed Matter,** Volume 403, Issues 5-9, April 2008, pp. 1487-1489.

"Dielectric Properties of Vitreous Silica with Various Hydroxyl Concentrations", Richard van Rooijen, Alexei Marchenkov, Hikota Akimoto, Reijer Jochemsen, Giorgio Frossati; **Journal of Low Temperature Physics**, Volume 110, Numbers 1-2, January 1998, pp. 269-274.

"Dynamics of Glass-Forming Liquids. VIII. Dielectric Signature of Probe Rotation and Bulk Dynamics In Branched Alkanes", Shervin Shahriari, Andrea Mandanici, Li-Min Wang, Ranko Richert; **The Journal of Chemical Physics**, Volume 121, Issue 18, November 8, 2004, pp. 8960-8967.

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"Correlations of structural, magnetic, and dielectric properties of undoped and doped $CaCu_3Ti_4O_{12}$", S. Krohns, J. Lu, P. Lunkenheimer, V. Brizé, C. Autret-Lambert, M. Gervais, F. Gervais, F. Bourée, F. Porcher, A. Loidl; **The European Physical Journal B - Condensed Matter and Complex Systems**, Volume 72, Number 2, November 2009, pp. 173-182.

"Dielectric Properties of Polypropylene Loaded with Synthetic Organoclay", Alexander Bulinski, Soli Bamji, Mahmoud Abou Dakka, Yaoren Chen; **2009 Annual Report – Conference on Electrical Insulation and Dielectric Phenomena**, October 18-21, 2009, Virginia Beach, Virginia.

2. CARBON NANOTUBES, NANOWIRES, QUANTUM DOTS

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"Measurement of The Quantum Capacitance of Interacting Electrons In Carbon Nanotubes", S. Ilani, L. A. K. Donev, M. Kindermann, P. L. McEuen; **Nature Physics**, Volume 2, Issue 10, October 2006, pp. 687-691.

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"Quantum Capacitance Measurement for SWNT FET with Thin ALD High-k Dielectric", Yuerui Lu, Hongjie Dai, Yoshio Nishi; **65th Device Research Conference**, The University of Notre Dame, South Bend, Indiana, June 18-20, 2007, Conference Digest.

"Measuring the Capacitance of Individual Semiconductor Nanowires for Carrier Mobility Assessment" Ryan Tu, Li Zhang, Yoshio Nishi, Hongjie Dai; **Nano Letters**, 2007, Volume 7, Number 6, pp. 1561-1565.

"Hole Levels in InAs Self-Assembled Quantum Dots", J. H. Blokland, F. J. P. Wijnen, P. C. M. Christianen, U. Zeitler, J. C. Maan, P. Kailuweit, D. Reuter, A. D. Wieck; **Physical Review B**, June 2007, Issue 75, Issue 23, p. 233305.

"Quantitative Scanning Capacitance Microscopy On Single Subsurface InAs Quantum Dots", J. Smoliner, W. Brezna, P. Klang, A. M. Andrews, G. Strasser; **Applied Physics Letters**, Volume 92, Issue 9, 2008 p. 092112.

"Diameter-Dependent Electron Mobility of InAs Nanowires", Alexandra C. Ford, Johnny C. Ho, Yu-Lun Chueh, Yu-Chih Tseng, Zhiyong Fan, Jing Guo, Jeffrey Bokor, Ali Javey**; Nano Letters,** Volume 9, Number 1, 2009, pp. 360-365.

"Dopant Profiling and Surface Analysis of Silicon Nanowires Using Capacitance–Voltage Measurements", Erik C. Garnett, Yu-Chih Tseng, Devesh R. Khanal, Junqiao Wu, Jeffrey Bokor, Peidong Yang; **Nature Nanotechnology,** Volume 4, Number 5, May 2009, pp. 311-314.

"Measurement of Carrier Mobility in Silicon Nanowires", Oki Gunawan, Lidija Sekaric, Amlan Majumdar, Michael Rooks, Joerg Appenzeller, Jeffrey W. Sleight, Supratik Guha, Wilfried Haensch; **Nano Letters,** Volume 8, Number 6, 2008, pp. 1566-1571.

"Bottom-up growth of fully transparent contact layers of indium tin oxide nanowires for light-emitting devices", C. O'Dwyer, M. Szachowicz, G. Visimberga, V. Lavayen, S. B. Newcomb & C. M. Sotomayor Torres; **Nature Nanotechnology**, Volume 4, Issue 4, 2009, pp. 239-244.

"Advanced Capacitance Metrology for Nanoelectronic Device Characterization", Curt A. Richter, Joseph J. Kopanski, Chong Jiang, Yicheng Wang, M. Yaqub Afridi, Xiaoxiao Zhu, D. E. Ioannou, Qiliang Li; **Frontiers of Characterization and Metrology for Nanoelectronics**: 2009. AIP Conference Proceedings, Volume 1173, pp. 328-332.

3. DILATOMETRY -- (INCLUDES: THERMAL EXPANSION, and MAGNETOSTRICTION)

"Capacitance Cell Measurement of the Out-of-Plane Expansion of Thin Films", Chad R. Snyder and Frederick I. Mopsik; **National Institute of Standards and Technology (NIST),** Special Publication 960-7.

Continuing on with examples of dilatometry, in **"A Tilted-Plate Capacitance Displacement Sensor",** Jan Genossar, and Michael Steinitz, **Review of Scientific Instruments**, Volume 61, Issue 9, September 1990, pp. 2469-2470, these authors continue their earlier work and use a high-precision manual capacitance bridge to measure small changes in displacement of various materials as well as the detection of small changes in angle. Steinitz has added an **AH2500A** automatic capacitance bridge to his arsenal of tools for his dilatometry work and has developed a high temperature capacitance dilatometer with a resolution of better than 1 Angstrom. This allows users to measure changes of length or position with Angstrom resolution at temperatures of up to 1500 degrees C. (Michael Steinitz, Prof. of Physics at St. Francis Xavier University, Antigonish, Nova Scotia, Canada.)

M. Rotter, H. Muller, and E. Gratz, at the Technical University of Vienna and M. Doerr and M. Loewenhaupt, at the University of Technology Dresden, published **"A Miniature Capacitance Dilatometer For Thermal Expansion and Magnetostriction"**, **Review of Scientific Instruments**, Volume 69, Issue 7, July 1998, pp. 2742-2746. The authors say that capacitance "is one of the most sensitive methods for measuring small length changes of solids." They measure the changes in capacitance with an **AH2500A** bridge.

In **"A Precision Capacitance Cell For Measurement of Thin Film Out-of-Plane Expansion. I. Thermal Expansion"**, Chad R. Snyder and Frederick I. Mopsik; **Review of Scientific Instruments**, Volume 69, Issue 11, November 1988, pp. 3889-3895, use a **AH2500A** bridge in their work involving the measurement of the out-of-plane expansion of thin films, using a 3-terminal parallel plate capacitor cell. They looked at both single crystal <0001> oriented aluminum oxide and at Cyclotene (a thin film polymer made by Dow Chemical).

Another example of the versatility of capacitance as a measuring tool is noted in **"Temperature and Magnetic Field Dependence of The Lattice Constant In The Spin-Peierls Cuprate $CuGeO_3$ Studied By Capacitance Dilatometry In Fields Up To 16 Tesla"**, T. Lorenz, U. Ammerahl, T. Auweiler, B. Büchner, A. Revcolevschi and G. Dhalenne, while at the Universitat zu Koln along with others from Universite Paris-Sud (**Physical Review B**, Volume 55, Issue 9, March 1, 1997, pp. 5914-5928). The authors note that the Andeen-Hagerling capacitance bridge can principally resolve length changes of less than 0.01 angstrom, though because of mechanical vibrations in the system, one decade of sensitivity is lost. Thus, using a high-resolution capacitance dilatometer, the authors studied the temperature and field dependence of the lattice constant *a* via measurements of the thermal expansion (direct capacitance measurements of length changes with changes in temperature) and the magnetostriction (temperature held constant, length / capacitance changes as the magnetic field was swept).

"Thermal Expansion and Magnetostriction of $Ce_{1-x}La_xRhIn_5$", Shawna Hollen; NHMFL (National High Magnetic Field Laboratory)

"Magnetic and Magnetoelastic Behavior of Epitaxial $TbFe_2$ /Yfe_2 Bilayers", C. de la Fuente, J. I. Arnaudas, M. Ciria, A. del Moral, C. Dufour, A. Mougin, K. Dumesnil; **Physical Review B**, Volume 63, Issue 5, February 1, 2001, p. 054417.

"Thermal Expansion Study of Ordered and Disordered Fe_3A1: An Effective Approach for the Determination of Vibrational Entropy", Goutam Dev Mukherjee, C. Bansal, Ashok Chatterjee; **Physical Review Letters**, Volume 76, Issue 11, March 11, 1996, pp. 1876-1879.

The Department of Physics at **Montana State University** has developed a **high-resolution quartz-based capacitive thermal expansion system** using an **AH2500A** bridge along with a quartz dilatometer cell to detect length changes of 0.1 angstrom on a 1 mm long sample. Dr. John Neumeier notes that "this is comparable to detecting a change in length of the distance from New York City to San Francisco of 3 inches!" A sample of their work is described in: **"Negative Thermal Expansion of M_gB_2 in the Superconducting State and Anomalous Behavior of The Bulk Grüneisen Function"**, J. J. Neumeier, T. Tomita, M. Debessai, J. S. Shilling, P. W. Barnes, D. G. Hinks, J. J. Jorgensen; **Physical Review B**, Volume 72, Issue 22, December 1, 2001, p. 220505.

"Capacitance Dilatometry Moves From Cryogenic to High Temperatures", M. O. Steinitz; **Physics in Canada**, Volume 62, Number 2, March/April 2006.

"Anisotropic Thermal Expansion and Magnetostriction of YNi_2B_2C Single Crystals", S. L. Bud'ko, G. M. Schmiedeshoff, G. Lapertot, P. C. Canfield; **Journal of Physics: Condensed Matter**, Volume 18, Issue 35, September 2006, pp. 8353-8365.

“A Versatile and Compact Capacitive Dilatometer”, G. M. Schmiedeshoff, A. W. Lounsbury, D. J. Luna, S. J. Tracy, A. J. Schramm, S. W. Tozer, V. F. Correa, S. T. Hannahs, T. P. Murphy, E. C. Palm, A. H. Lacerda, S. L. Bud’ko, P. C. Canfield, J. L. Smith, J. C. Lashley, J. C. Cooley; **Review of Scientific Instruments**, Volume 77, Issue 12, December 28, 2006, p. 123907.

“Magnetostriction in the Bose-Einstein Condensate quantum magnet $NiCl_2$-$4SC(NH_2)_2$”, V. S. Zapf, V. F. Correa, C. D. Batista, T. P. Murphy, E. D. Palm, M. Jaime, S. Tozer, A. Lacerda, A. Paduan-Filho; **Journal of Applied Physics,** Volume 101, Issue 9, May 1, 2007, Article 09E106.

“Electronic Restructuring in Shape-Memory Alloys: Thermodynamic and electronic structure studies of the martensitic transition”, J. C. Lashley, R. K. Schulze, B. Mihaila, W. L. Hults, J. L. Smith, P. S. Risenborogh, C. P. Opeil, R. A. Fisher, O. Svietelskiy, A. Suslov, A. Planes, L. Manosa, T. R. Finlayson; **Physical Review B**, Volume 75, Issue 20, 2007, p. 205119**.**

“Correlation Between Magnetostriction and Polarization In Orthorhombic Manganites”, Iliya Radulov, Vassil Lovchinov, Dimitar Dimitrov, Viktor Nizhankovskii; **arXiv:0705.2022** V1, May 14, 2007.

“Simultaneous Measurements of Thermal Expansion and Thermal Conductivity of FRPS By Employing A Hybrid Measuring Head On A GM Refrigerator”, S. Kanagaraj, S. Pattanayak; **Cryogenics**, Volume 43, Issue 8, August 2003, pp. 451-458.

“A Microfabricated Sensor For Thin Dielectric Layers”, P. Fierlinger, R. DeVoe, B. Flatt, G. Gratta, M. Green, S. Kolkowitz, F. Leport, M. Montero Diez, R. Neilson, K. O'Sullivan, A. Pocar, J. Wodin; **Review of Scientific Instruments,** Volume 79, Issue 4, April 2008, p. 045101.

“A Precision Capacitance Cell for Measurement of Thin Film Out-of-Plane Expansion – Part III: Conducting and Semiconducting Materials”, Chad R. Snyder, Frederick I. Mopsik; **IEEE Transactions on Instrumentation and Measurement**, Volume 50, Number 5, October 2001, pp. 1212-1215.

“Direct Measurement of the Thermal Expansion of Liquid ^3He”, D. L. Sawkey, D. Deptuck, J. P. Harrison; **Journal of Low Temperature Physics,** Volume 116, Numbers 5-6, September 1999, pp. 433-441.

“Pinning of the Vortex System and Magnetostriction of Superconductors”, A. Nabiaek, H. Szymczak, V. V. Chabanenko; **Journal of Low Temperature Physics**, Volume 139, Number 1, April 2005, pp. 309-330.

“Temperature behavior of the protonic conductor $K_4LiH_3(SO_4)_4$”, A. Haznar, A. Pietraszko; **Journal of Solid State Chemistry**, Volume 177, Issue 6, June 2004, pp. 2150-2157.

“Ytterbium Divalency and Lattice Disorder In Near-Zero Thermal Expansion YbGaGe”, C. H. Booth, A. D. Christianson, J. M. Lawrence, L. D. Pham, J. C. Lashley, F. R. Drymiotis; **Physical Review B,** Volume 75, Issue 1, 2007, p. 012301.

Supplementary information for **“Ytterbium Divalency and Lattice Disorder In Near-Zero Thermal Expansion YbGaGe”,** C. H. Booth, L. Pham, A. Christianson, F. R. Drymiotis, J. Lashley. This electronic supplement contains some extra experimental details.

“Capacitive-based dilatometer cell constructed of fused quartz for measuring the thermal expansion of solids”, J. J. Neumeier, R. K. Bollinger, G. E. Timmins, C. R. Lane, R. D. Krogstad, J. Macaluso; **Review of Scientific Instruments**, Volume 79, Issue 3, March 2008, pp. 033903-033903-8.

“Dimensional Crossover in the Purple Bronze $Li_{0.9}Mo_6O_{17}$”, C. A. M. dos Santos, B. D. White, Yi-Kuo Yu, J. J. Neumeier, J. A. Souza; **Physical Review Letters,** Volume 98, Issue 26, June 2007, p. 266405.

"**Peculiarities of the magnetic-history-dependent phase in CePtSn",** Jan Prokleska, Blanka Detlefs, Vladimír Sechovsky, Martin Mísek; **Journal of Magnetism and Magnetic Materials**, Volume 322, Issues 9-12, May-June 2010, pp. 1120-1122.

4. FERROELECTRICS

Donavan Hall, D. P. Young, Z. Fisk, T. P. Murphy, E. C. Palm, A. Teklu, and R. G. Goodrich at the NHFML, Florida State University, Tallahassee, FL, et. al., used a precision capacitance bridge to measure the gap between a torque cantilever device and a fixed/reference plate in **"Fermi Surface Measurements on the Low Carrier Density Ferromagnet $Ca_{1-x}La_xB_6$ and SrB_6"**, **Physical Review B**, Volume 64, Issue 23, December 15, 2001, p. 233105.

"The Anchoring Energy of Nematic Molecules On Magnetic Particles In Some Types of Ferronematics", P. Kopcansky, I. Potocova, M. Koneracka, M. Timko, A. G. M. Jansen, J. Jadzyn, G. Czechowski; **10th International Conference on Magnetic Fluids**, Guarujá, São Paulo, Brazil, August 2-6, 2004.

"Coupling of Magnetic Order, Ferroelectricity, and Lattice Strain in Multiferroic Rare Earth Manganites", B. Lorenz, C. R. dela Cruz, F. Yen, Y. Q. Wang, Y. Y. Sun, C. W. Chu; **Proceedings of the ACERS Annual Meeting**, Baltimore, Maryland, April 10-13, 2005.

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7. LOW TEMPERATURE PHYSICS

Many of our bridges are used in the laboratories of universities and private firms. Several articles have been written referencing our bridges for use in low-temperature work where high-resolution capacitive pressure gauges are used. An excellent review article was written by Dwight Adams, (E. Dwight Adams, **"High-Resolution Capacitive Pressure Gauges"**, **Review of Scientific Instruments**, Volume 64, Issue 3, March 1993, pp. 601-611). The **AH2500A** capacitance bridge can be utilized (and is referenced in the article) to measure the capacitance of these gauges. Some specific applications include:

measurement of sample pressure or density, as in the study of solid helium;
pressure regulation in a low temperature cell (4.2 K);
thermodynamic measurements as with studies of solid ^{3}He;
internal and miniature strain gauges within a sample cell;

thermometry:
- melting(curve) pressure thermometry;
- vapor pressure thermometry;
- gas pressure thermometry.

differential and low-pressure gauges:
- studies of critical velocity in superfluid ^{4}He;
- equation of state of spin-polarized hydrogen;
- vortex creation in the flow of superfluid ^{4}He through an aperture;
- flow in superfluid ^{3}He;
- magnetically driven superflow and magnetic relaxation in ^{3}He-A_1.

Much work is done in low-temperature thermometry using the Andeen-Hagerling, Inc. capacitance bridge where the use of a capacitive pressure sensor is quite common from 700 mK down to 1 mK and below. An example of a Straty-Adams pressure gauge used as a thermometer in conjunction with the **AH2500A** capacitance bridge is described in **"Unconventional Quantized Vortices: A Study on ^{3}He and UPt_3"** **Dissertation of Rob Blaauwgeers**, University of Leiden, The Netherlands, June 6, 2002, pp. 23-25. In this example, the bridge gives a resolution better than

0.00005 pF, although it is stated that a small interference on the signal limited the precision to this level, with a relative accuracy in the temperature measurement of about 10^{-4} at 2.5 mK. Pressure sensitivity was 10 μbar, and for temperatures between 1 and 250 mK the Greywall temperature scale was used.

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NOTE TO OUR READERS: If you have published an article that is not mentioned in this document referencing the use of one of our instruments, please let us know about it. Capacitance is a powerful tool for many situations. However, it takes continuous proof by example to show its value among so many other competing technologies.