Pressure cell for magnetostrictive measurements

Jerome E. Ostenson
Iowa State University

Douglas K. Finnemore
Iowa State University, finnemor@ameslab.gov

David C. Jiles
Iowa State University, dcjiles@iastate.edu

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Pressure cell for magnetostrictive measurements

Abstract
A pressure cell has been designed to study the magnetostrictive properties of a material as a function of both pressure and magnetic field. For changes in length on the order of 2000 ppm, it is necessary to have a substantial compliance in the pressure cell to retain a constant stress over the length of travel.

Keywords
Physics, CNDE, Materials properties, Magnetic field measurements, Magnetic fields, Magnetic materials, Pressure management

Disciplines
Electromagnetics and Photonics | Engineering Physics

Comments
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small degrees of upward curvature in the cross sections. This trend reverses at 4–6 eV above threshold. In the present context the feature of greatest interest is the clear superiority of He as a calibrant gas. In this case the linear regression analysis can include data to 8 eV above threshold without incurring any significant systematic error. The next best choice is Xe, for which the systematic error remains below 0.07 eV out to 7 eV above threshold. The worst choice is argon, for which the error increases rapidly with the range of the fit, and can exceed 0.3 eV.

In applying this method for either energy scale calibration or appearance potential measurements, the cross section cannot be assumed a priori to be linear over the required range. The user must be satisfied that the experimental data has a linear region extending for at least a few times the energy spread of the beam, and, having set the linear fit, the region of curvature at the “toe” of the appearance curve must be consistent with the known energy spread of the electron beam. If the cross-section behavior were ideal the second derivative of the appearance curve would correspond exactly to the energy distribution in the beam, reversed on the energy scale. Such an analysis requires very good signal-to-noise ratio in this inherently weak signal region. The simplest approach to this question is to visually compare the “unknown” appearance curve to that of He or Xe obtained with the same electron beam. If the extent of the “toe” significantly exceeds that in the reference gas, the real curvature in the cross-section shape must be taken into account, requiring a more detailed deconvolution procedure.

Pressure cell for magnetostrictive measurements

J. E. Ostenson and D. K. Finnemore

Ames Laboratory-USDOE and Department of Physics, Iowa State University, Ames, Iowa 50011

D. C. Jiles

Center for Non-Destructive Evaluation, Ames Laboratory-USDOE, Iowa State University, Ames, Iowa 50011

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A pressure cell has been designed to study the magnetostrictive properties of a material as a function of both pressure and magnetic field. For changes in length on the order of 2000 ppm, it is necessary to have a substantial compliance in the pressure cell to retain a constant stress over the length of travel.

Several new materials having a “giant” magnetostriction have recently been developed for use in sonar applications. In the course of developing processing procedures for these materials, it was necessary to simultaneously measure both the magnetic hysteresis curves ($B$ versus $H$) and the magnetostrictive curves ($\lambda$ versus $H$) while at the same time maintaining a constant stress on the sample. The magnetostrictive performance of the material changed substantially with
many different processing variables so it was necessary to develop a fast, reliable, and relatively easy procedure to measure all of these quantities simultaneously on the same sample.\textsuperscript{2,3} We report here the design of a special pressure cell, well suited for applying a uniaxial force during the measurements for routine diagnostic work on any magnetostrictive material of this type.

Basic requirements of the cell are (1) to apply a constant pressure on a sample ranging from 0–14 MPa while the length is changing by about 0.2 mm; (2) to measure both magnetic induction, $B$, and the magnetic field, $H$, as the sample cycles around a hysteresis loop; and (3) measure the magnetostrictive length change, $\lambda$, versus $H$ or $B$. To do this, a pressure cell was fabricated using welded metal bellows which were 47.6 mm (1½ in.) o.d. by 34.9 mm (1½ in.) i.d. as shown in Fig. 1. The bellows were soldered between a ferromagnetic baseplate adjacent to the magnet pole piece and a nonmagnetic end piece adjacent to the sample as shown. This nonmagnetic end piece was recessed into the bellows to minimize the gap in the magnetic circuit. If the baseplate were nonmagnetic, the gap in the magnetic circuit would double. Measurements show that this larger gap would give a variation in $H$ along the sample of over 6%. With the magnetic baseplate on the cell this variation is reduced to about 2.5% in spite of any distortion of the field due to the nonsymmetric pole pieces. Welded metal bellows with a very low spring constant were chosen to minimize the force coming from the bellows itself. A gas cylinder was used to pressurize a variation in $\lambda$ with screw threads on the pole piece adjustment mechanism. The magnet pole piece position was adjusted to give approximately 1 mm separation between the baseplate and the sample end piece. The space for the sample was adjustable to any desired length. Adjustment of the pole position was made with screw threads on the pole piece adjustment mechanism. The poles were then locked in place with wedges to eliminate any motion of the poles which would introduce spurious artifacts in the data.

Calibration of the cell was made in a standard tensile/compression test machine. For this particular cell a gas pressure of 16 kPa gives a uniaxial force of 4.5 N. The magnetic induction ($B$) was measured by integrating the voltage from a 100 turn pickup coil wrapped directly on the sample. The magnetic field ($H$) was determined by a Hall probe which was modified to measure $B$ parallel to the sample in air just outside the sample surface. Here $B_0$ (outside) = $\mu_0 H_0$ (outside) = $\mu_0 H_0$ (inside) by the usual boundary condition giving $H_0$ continuity. Some difficulty was encountered in keeping the sample ends from chipping since the terfenol samples were very brittle. A thin rubber pad on each end of the sample proved to be a suitable pressure transmitting medium while minimizing the chipping problem.

A computer controlled magnet power supply was used to slowly cycle through hysteresis loops.\textsuperscript{4} Values for $B$, $H$, and $\lambda$ were collected on the third of three cycles around the loop. Typical data are shown for $\lambda$ versus $H$ and $B$ versus $H$ in Fig. 2.

With this apparatus, diagnostic work on a given sample takes about an hour. This implies a very fast turn-around time on evaluating the magnetic properties of any desired material under stress.
Integrating multichannel scaler for photon counting in laser radar application

Maurizio Viterbini and Alberto Adriani

Istituto Fisica dell’Atmosfera, C.N.R., c.p. 27, 00044, Frascati, R.M. Italy

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A multichannel scaler for photon counting is described. Single photon pulses can be collected up to rates of 100 MHz during a programmed dwell time and an integration versus time can be done for each of the 999 channels on a user-programmable number of successive measurements. A live, dynamic display is provided. Data can be easily sent to any computer for recording or to a telemetry system for remote transmission.

In the field of optical active remote sensing of the atmosphere, peculiar instrumentation has to be used to detect very low level light echoes. In particular, for vertical sounding (light detection and ranging) (LIDAR) applications, dynamics of the received optical echoes are very high, decaying in magnitude according to the exponential-like distribution of the atmospheric density versus height and the inverse square power of the latter. For this reason, the received signal changes from analogical to the single photon regime at ranges longer than 35–40 km, and a photon counting system is required. Other instruments had been developed by different researchers for single photon counting. In this context, the multichannel scaler, described in this note, was developed at the end of 1987 to improve the performance of a LIDAR system working at Frascati laboratories for studying the structure and dynamics of the middle atmosphere; later, some IBM PC and CAMAC boards became available for that purpose.

A block diagram of the multichannel scaler is shown in Fig. 1. It consists in a programmable delay generator after which a fast 16 bit counter is enabled to count for all the dwell times set by the programmable width gate generator. A programmable number of gates defines the atmospheric layers to examine and, at any end of each gate, data are stored and added at the RAM memory data words relative to the same atmospheric layer. The new result replaces the old one in the memory and is sent to a D/A converter to get a live display too. Any integration needs about 1 μs.

Besides the specific reason for which the instrument has been conceived, it can be used in all those experiments in which a measurement versus time of any event is necessary. Its flexibility and its self-consistency make it suitable mainly for measurements in "remote" conditions, being thoroughly user programmable in all its features, such as delay time from trigger, number of successive temporal gates during which pulses are stored, gate width, and number of the measurements to be integrated in real time. Its very simple hand-command interface has been designed to make it suitable for use by different experts in the field.

TABLE I. Multichannel scaler’s salient features.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count rate</td>
<td>up to 100 MHz</td>
</tr>
<tr>
<td>Programmable delay</td>
<td>up to 999 μs</td>
</tr>
<tr>
<td>Dwell time</td>
<td>up to 99.9 μs (min step 1 μs)</td>
</tr>
<tr>
<td>Gate number</td>
<td>up to 999</td>
</tr>
<tr>
<td>Integration number</td>
<td>up to 9999</td>
</tr>
<tr>
<td>Time lag between gates</td>
<td>min 50 ns</td>
</tr>
</tbody>
</table>

Fig. 1. Integrating multichannel scaler block diagram.