

**DEVELOPMENT OF A BACKSCATTER MÖSSBAUER SPECTROMETER (BaMS) FOR PLANETARY APPLICATIONS;** T.D. Shelfer, M.M. Pimperl, E.L. Wills, D.G. Agresti, Department of Physics, University of Alabama at Birmingham, Birmingham, AL 35294; and R.V. Morris, Code SN2, NASA Johnson Space Center, Houston, TX 77058.

**Introduction.** We have proposed the use of Mössbauer spectroscopy on planetary surfaces [1], since such measurements provide information on the state of iron in solid surface materials and can be interpreted in terms of planetary evolution and current environmental conditions. Possible near-term NASA efforts that would benefit from such analysis include missions to Mars (MESUR, 1998) and the moon (Lunar Resource Evaluation).

In developing the BaMS instrument, we have focussed on optimizing key elements of the spectrometer, especially the velocity transducer (drive) and the backscatter radiation detector. We are also constructing a single-board electronics package for control and data storage, which will be combined with the drive and detector to complete the miniaturized spectrometer suitable for use on a planetary surface. Ultimately, the instrument will have XRF capability as well.

**Velocity transducer.** We have developed and constructed a "microdrive," shown schematically in figure 1, which, at 18 grams and 5.3 cm<sup>3</sup>, is less than 1% the mass and volume of a typical laboratory transducer. It is based on the Kankeleit double-loudspeaker design [2]. The response of the microdrive to a sinusoidal input voltage of constant amplitude (100 mV) is shown in figure 2 as amplitude and phase shift of voltage induced in the pickup coil. Ideally, drive motion should follow a triangular velocity waveform (constant acceleration mode) to sample all velocities equally. From the figure, we see that a sufficient range of frequencies is available for good feedback control, e.g. at ~100 Hz to limit displacement to a few  $\mu\text{m}$ , before positive feedback (ringing) occurs above ~7 kHz. Figure 3 shows the variation of resonant frequency (corresponding to the voltage maximum in figure 2) with mass attached to the moving central shaft (unloaded = 1.8 gram). The drive behaves as a simple harmonic oscillator with a spring constant of  $\sim 1.0 \times 10^4$  N/m. We are currently implementing a feedback circuit to control this drive for Mössbauer operation.

We have previously investigated a multi-element PZT piezoelectric transducer as a solid-state alternative to the standard two-coil drive. Results of our tests were not satisfactory [3] and led us to construct the microdrive. We are currently testing a lead-manganese-niobate (PMN) electrostrictive translator [Queensgate MT45] which exhibits a 45- $\mu\text{m}$  excursion at 175 V. Based on manufacturer specifications, we anticipate more likely success with this device. Our findings will be presented at the meeting.

**Backscatter detector.** Figure 4 is a sketch of a gas-filled proportional counter under development as a  $2\pi$ -backscatter detector for possible use in the BaMS instrument. Collimated, velocity-modulated 14.4-keV  $\gamma$  radiation from the <sup>57</sup>Co source enters the small window at the top and continues through the bottom window to interact with the surface material immediately below. The 6.4-keV x radiation produced following resonant absorption by <sup>57</sup>Fe nuclei in this material backscatters upward into the detector and is recorded during the Mössbauer experiment. To reduce the x-ray background from the source, ~90  $\mu\text{m}$  of aluminum is placed over the entrance window (10% 6.4-keV, 80% 14.4-keV transmitted). The detector thickness is optimized in a similar fashion, maximizing absorption efficiency at 6.4 keV without seriously sacrificing transmission at 14.4 keV. Figure 5 shows a pulse height spectrum obtained with this detector. The x- and  $\gamma$ -ray peaks are well resolved. We will present representative backscatter Mössbauer spectra obtained with this detector at the meeting.

We have reported measurements with HgI<sub>2</sub> solid-state detectors that demonstrate their suitability for BaMS provided a  $2\pi$  array of such detectors could be constructed [4]. The use of PIN diodes as detectors has been reported [5], and we are pursuing this alternative as well.

**References:** [1] Morris *et al.* (1989) *Lun. Planet. Sci.* XX, 723; [2] Kankeleit (1965) *Mössbauer Effect Methodology*, Vol. 1, 47; [3] Shelfer *et al.* (1991) *Lun. Planet. Sci.* XXII, 1229; [4] Agresti *et al.* (1990) *Lun. Planet. Sci.* XXI, 5; [5] Klingelhöfer *et al.* (1991) *Hyperfine Interactions*, in press.

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Figure 1. Microdrive schematic.

Drive coil:  
64 turns; 40-gauge wire (11.4 Ω)

Pickup coil:  
642 turns; 51-gauge wire (790 Ω)

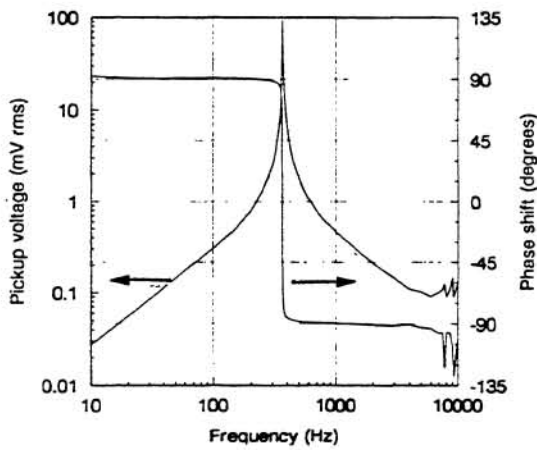
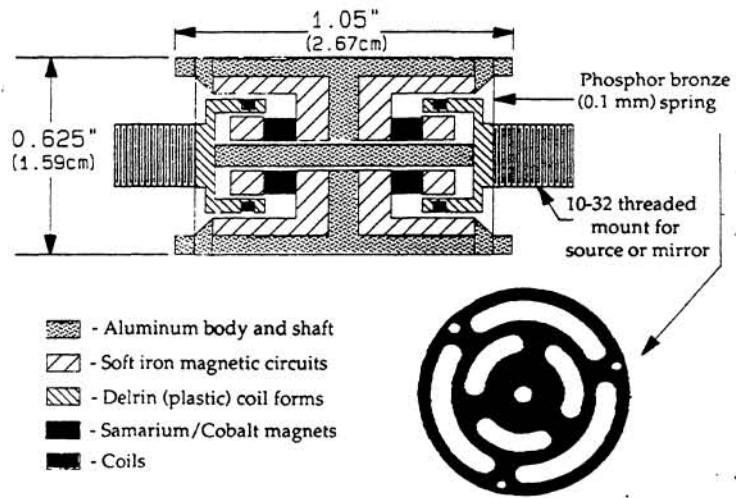


Figure 2. Microdrive response.

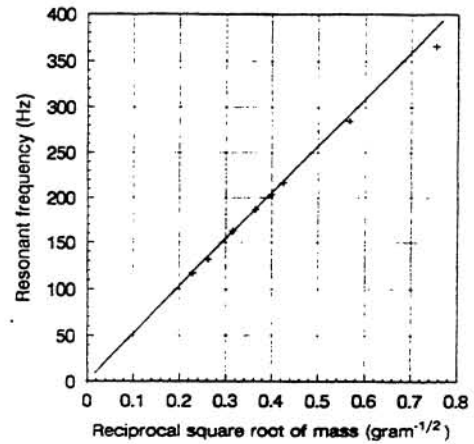


Figure 3. Microdrive loading function.

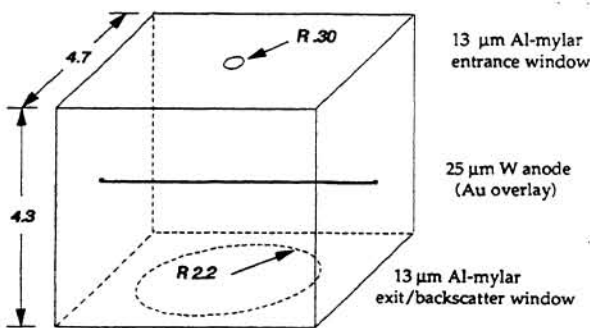


Figure 4. Backscatter detector schematic. Dimensions in cm.

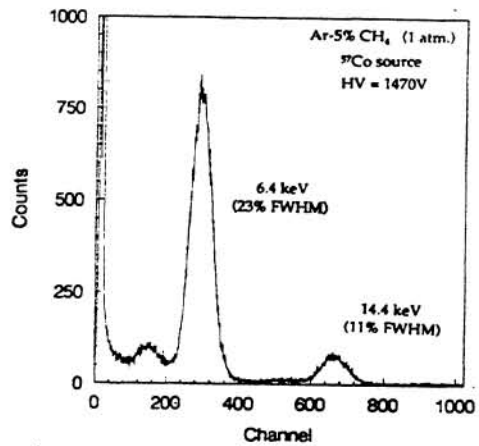


Figure 5. Sample pulse-height spectrum.