THE ADVANCED MINIATURISED MÖSSBAUER SPECTROMETER MIMOS IIA: INCREASED SENSITIVITY AND NEW CAPABILITY OF ELEMENTAL ANALYSIS. G. Klingelhöfer[1], D. Rodionov[1,2], M. Blumers[1], L. Strüder[3], P. Lechner[7], B. Bernhardt[4], H. Henkel[4], I. Fleischer[1], C. Schröder[1,5], J. Girones Lopez[1], G. Studlek[1], J. Maul[1], J. Fernandez-Sanchez[1], C. d'Uston[6]. [1]Johannes Gutenberg Universität Mainz, Institut für Anorganische und Analytische Chemie, Staudinger Weg 9, D-55099 Mainz, Germany (klingel@mail.uni-mainz.de). [2]Space Research Institute IKI, Moscow, Russia. [3]MPI Halbleiterlabor, München, Germany. [4]Von Hoerner&Sulger GmbH, Schwetzingen, Germany. [5]NASA Johnson Space Center, Houston, Texas, USA, [6]CESR Toulouse, France. [7]PNSensor GmbH, Munich, Germany.

Introduction: The two Miniaturised Mössbauer Spectrometers MIMOS II (Fig. 1) on board the two Mars Exploration Rovers "Spirit" and "Opportunity" have now been collecting important scientific data for more than four years [1]-[4]. The MER mission has proven that Mössbauer spectroscopy is an important tool for the in situ exploration of extraterrestrial bodies, in particular the study of Fe-bearing material. The total number of targets analized to date exceeds 600, the total integration time exceeds 260 days for each rover. The experience gained during the MER mission makes MIMOS II an obvious choice for future missions to Mars and other targets. Currently, MIMOS II is part of the scientific payload of the approved missions Phobos-Grunt (Russian Space Agency), scheduled for 2009, and the ExoMars mission (European Space Agency) , scheduled for launch in 2013, respectively.

Figure 1: The MER type version of the MIMOS II sensorhead with approximate dimensions 95 mm x 45 mm x 40 mm.

The main goals of the Phobos Grunt mission are: a) Phobos regolith sample return, b) In situ study of the surface of the Mars moon Phobos, c) Mars and Phobos remote sensing. MIMOS II will be installed on the robotic arm of the landing module.

The ESA ExoMars mission involves the development of a MER-like rover with a more complex scientific payload than on MER (Pasteur Exobiology instrument suite including a drilling system). Its goal is to further characterise the biological environment on Mars in preparation for future robotic missions and then human exploration. Data from the mission will provide important input for broader "exobiology" studies, the search for life on other planets. Like on MER, the MIMOS II instrument will be mounted on a robotic arm.

The design of the advanced and improved version of the MIMOS II instrument includes additional mass reduction with a total mass of ~320 g, as compared to ~450 g of the MER instruments. The dimensions of the electronic-board will be minimized by using state of the art digital electronics. A new ring detector system (Si-Drift detectors, SDD (see Fig.3; basic design)) will replace the four Si-PIN detectors of the current version, greatly improving the energy resolution (Fig. 6).

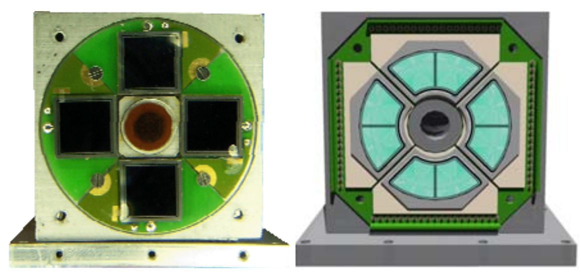

Figure 2: The MER type instrument (left) features four Si PIN detectors with a total sensitive area of 400 mm^2, while the advanced MIMOS IIA instrument has a ring detector system composed of 8 SDD segments with a total sensitive area of ~ 360 mm^2.

For temperatures lower than 250 K, an energy resolution of ~140-160 eV is expected (Fig. 4). This will increase the signal to noise ratio by a factor of ~10 and, therefore, either integration times can be reduced significantly or data quality can be improved significantly in comparison to the MER instruments. Fig. 5 shows backscatter Mössbauer spectra obtained on a sample of Ortenberg basalt with a high resolution Si drift detector system [5]. The 14.4 keV γ-ray-spectrum (top) shows a resonance effect of ε=73%; the 6.4 keV Kα-Fe-X-ray spectrum (bottom) shows a resonance effect of ε=19%. For comparison, using the Si-PIN detector system gives a value of only ε=4% for 14.4 keV radiation [1].

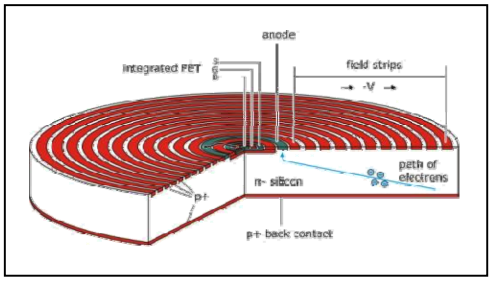

Figure 3: design scheme of the SDD chip [8]

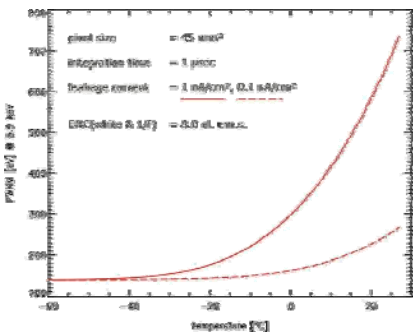

Figure 4: range of expected energy resolution with Si drift detectors [6].

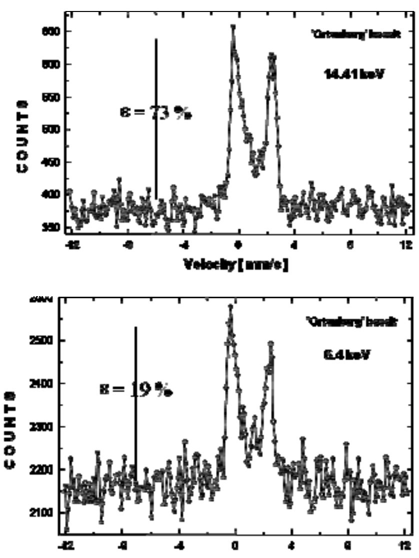

Figure 5: Backscatter Mössbauer spectra of Ortenberg basalt. The 14.41 keV spectrum shows a resonance effect of ε=73%, as compared to a value of only ε=4% using a Si PIN detector system [5].

In addition to the Mössbauer data, Si drift detectors allow the simultaneous acquisition of the X-ray fluorescence spectrum, thus providing data on the sample's elemental composition. Fig. 6 shows the X-ray spectrum taken with a high resolution Si drift detector with a small sensitive area of 5 mm^2. New firmware is being developed to optimize the instrument's performance.

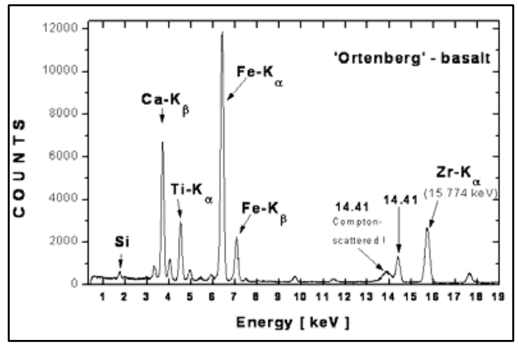

Figure 6: X-ray spectrum of Ortenberg basalt taken with a high resolution SDD (sensitive area 5mm^2); ambient pressure (1 atm), therefore low energy X-rays are surpressed. [5].

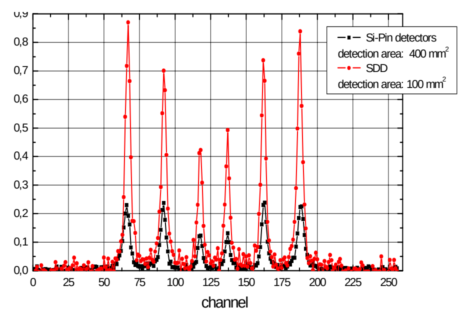

Figure 7: 14.41 keV Backscatter Mössbauer spectra of an Fe-foil taken with SDD (red) and Si PIN detector system (black). Note: sensitive area of SDD (100 mm^2) is only ¼ of the Si-PIN detector system (400 mm^2).

Summary: The use of new detector technologies and electronic components will result in significant increase in sensitivity and performance of the advanced model of MIMOS II. The high energy resolution of the SDD will allow X-ray fluorescence analysis in parallel to Mössbauer spectroscopy.

Acknowledgements: The development of the advanced MIMOS II instrument is funded by the German Space Agency DLR under contract 50QX0603.

References: [1] Klingelhöfer et al., J. Geophys. Res. 108(E12) (2003) [2] Klingelhöfer et al., Science 306 (2004) 1740-1745. [3] Morris et al., Science 305 (2004) 833-836. [4] Morris et al., J. Geophys. Res. 111 (2006) [5] Klingelhöfer (1999); in: Mössbauer Spectroscopy in Materials Science, eds. M.Miglierini and D.Petridis, Kluwer Academic Publishers 1999. [6] Strüder, Lechner, Leutenegger, Naturwissenschaften, No. 11, 539-543 (1998).