MEMS for Space

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Future space exploration will emphasize cost effectiveness and highly focused mission objectives. MEMS will be one of the enabling technologies to create low cost, ultra-miniaturized payloads, as well as highly capable nano-satellites and eventually constellations of nano-satellites. Examples of such miniaturization and successful use of MEMS for space missions will be described.

Biological experiments in space have shown that important cellular functions are changed in micro-gravity. These findings are of great interest for fundamental research as well as for possible biotechnological applications. To analyze the modification during cell growth, a miniature bioreactor for the cultivation of yeast cells was designed and flown (1994, 1996 and 2003) aboard Spacelab on the Space Shuttle.
In view of the complexity of the instrument and the limited dimensions of the container (63x63x85mm), the application of MEMS technology to provide pH, temperature and redox sensors as well as a micro-machined pump and a flow sensor are not just an advantage but a necessity.

In a completely different field of research, the characterization airborne dust particles present in the Martian atmosphere will help to understand the seasonal variation of the Martian climate and the geological history of the planet. The Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) of the recent Phoenix mission to Mars included also an MEMS based Atomic Force Microscope (AFM). The AFM has been designed to analyze dust properties like shape, size distribution and hardness with nanometer resolution. The AFM has been successfully used on Mars and typical images as obtained with Martian dust particles will be presented.

Other examples of current and past developments of MEMS components and systems will be discussed, including novel miniaturized thrusters based on hot gas or ion emission, inertial sensors, and optical MEMS devices for on-board data transmission.

Finally the trend towards pico- and nano-satellites, which are increasingly deployed, will be highlighted. These 1 to 10 kg satellites can only achieve the required performance by using MEMS components, in particular for attitude control and determination, and are as such early adopters of MEMS technology in space.