Abstract for the 2002 IEEE Aerospace conference.

Micro Sun Sensor

Carl Christian Liebe
Sohrab Mobasser
Chris J. Wrigley
Youngsam Bae
Ayanna Howard
Jeffrey Schroeder

Two categories of conventional sun sensors exist - digital and analog types. The digital sun sensors illuminate a geometric pattern on the detector plane. The presence or absence of light in these well-defined areas defines a binary signal that can be translated into the sun angle. Analog sun sensors outputs analog currents that can be related to the sun angle. Conventional sun sensors typically determine the sun angle in one axis.

A new generation of sun sensors is emerging. These sun sensors utilize an imaging detector. The sun sensor determines the sun angles based on an image of fringes or centroids on the detector plane. This new generation of sun sensors typically determines the sun angle in two axes.

Future nano spacecraft and nano rovers will carry sun sensors to determine the pointing direction towards the sun. Conventional sun sensors are typically too large compared to the size of a nano spacecraft or a nano rover.

At Jet Propulsion Laboratory, California Institute of Technology there is an ongoing research task to design and develop a miniaturize sun sensor that will meet or exceed the current state of art sun sensor capabilities. A sun sensor with a mass of about 10 grams and the size of four quarters stacked on top of each other has been developed. This is more than an order of magnitude improvement over current sun sensors.

The small size has been achieved utilizing an Active Pixel Sensor (APS) imaging detector combined with a MEMS based multi aperture mask. The APS imaging detector contains all functions (including control logic and A/D converters) on the chip. The MEMS mask is placed 500 microns from the imaging detector. The Optical attenuation in the silicon MEMS mask and a thin layer of chrome results in a bright sun signal on the APS imaging detector without saturating it. Primarily wavelengths around 1 micron are detected. On the MEMS mask, there is also an opaque gold layer. In the gold layer, there is a rectangular grid of pinholes.

When the sun is illuminating the MEMS mask, the pinholes will illuminate the detector plane. The position of the pattern will depend on the angle of the sun. This is just like a sundial. Software algorithms are capable of converting the shadows into sun angles.

This paper will describe the concept, the silicon masks, the APS imaging detector, the packaging, the calibration, the algorithms and the performance.