



CRUQS: A Miniature Fine Sun Sensor for Nanosatellites

Size, mass, and power make the sensor suited to small satellite applications, especially nanosatellites.

Goddard Space Flight Center, Greenbelt, Maryland

A new miniature fine Sun sensor has been developed that uses a quadrant photodiode and housing to determine the Sun vector. Its size, mass, and power make it especially suited to small satellite applications, especially nanosatellites. Its accuracy is on the order of one arc-minute, and it will enable new science in the area of nanosatellites.

The motivation for this innovation was the need for high-performance Sun sensors in the nanosatellite category. The design idea comes out of the LISS (Lockheed Intermediate Sun Sensor) used by the sounding rocket program on their solar pointing ACS (Attitude Control System). This system uses photodiodes and a wall between them. The shadow cast by the Sun is used to determine the Sun angle. The new sensor

takes this concept and miniaturizes it. A cruciform shaped housing and a surface-mount quadrant photodiode package allow for a two-axis fine Sun sensor to be packaged into a space $\approx 1.25 \times 1 \times 0.25$ in. ($\approx 3.2 \times 2.5 \times 0.6$ cm). The circuitry to read the photodiodes is a simple transimpedance operational amplifier. This is much less complex than current small Sun sensors for nanosatellites that rely on photoarrays and processing of images to determine the Sun center. The simplicity of the circuit allows for a low power draw as well.

The sensor consists of housing with a cruciform machined in it. The cruciform walls are 0.5-mm thick and the center of the cruciform is situated over the center of the quadrant photodiode sensor. This allows for shadows to be cast on

each of the four photodiodes based on the angle of the Sun. A simple operational amplifier circuit is used to read the output of the photodiodes as a voltage. The voltage output of each photodiode is summed based on rows and columns, and then the values of both rows or both columns are differenced and divided by the sum of the voltages for all four photodiodes. The value of both difference over sums for the rows and columns is compared to a table or a polynomial fit (depending on processor power and accuracy requirements) to determine the angle of the Sun in the sensor frame.

This work was done by Scott Heatwole, Carl Snow, and Luis Santos of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16551-1

On-Chip Microfluidic Components for In Situ Analysis, Separation, and Detection of Amino Acids

This innovation can be integrated in a lab-on-a-chip device for biological and analytical instruments.

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The Astrobiology Analytical Laboratory at GSFC has identified amino acids in meteorites and returned cometary samples by using liquid chromatography-electrospray ionization time-of-flight mass spectrometry (LCMS). These organic species are key markers for life, having the property of chirality that can be used to distinguish biological from non-biological amino acids. One of the critical components in the benchtop instrument is liquid chromatography (LC) analytical column. The commercial LC analytical column is an over-250-mm-long and 4.6-mm-diameter stainless steel tube filled with functionized microbeads as stationary phase to separate the molecular species based on their chemistry. Miniaturization of this technique for spaceflight is compelling for future payloads for landed missions targeting astrobiology objectives.

A commercial liquid chromatography analytical column consists of an inert cylindrical tube filled with a stationary phase, i.e., microbeads, that has been functionalized with a targeted chemistry. When analyte is sent through the column by a pressurized carrier fluid (typically a methanol/water mixture), compounds are separated in time due to differences in chemical interactions with the stationary phase. Different species of analyte molecules will interact more strongly with the column chemistry, and will therefore take longer to traverse the column. In this way, the column will separate molecular species based on their chemistry.

A lab-on-chip liquid analysis tool was developed. The microfluidic analytical column is capable of chromatographi-

cally separating biologically relevant classes of molecules based on their chemistry. For this analytical column, fabrication, low leak rate, and stationary phase incorporation of a serpentine microchannel were demonstrated that mimic the dimensions of a commercial LC column within a $5 \times 10 \times 1$ mm chip. The microchannel in the chip has a 75-micrometer-diameter oval-shaped cross section. The serpentine microchannel has four different lengths: 40, 60, 80, and 100 mm. Functionalized microbeads were filled inside the microchannel to separate molecular species based on their chemistry.

This microscale analytic chip is designed to integrate with miniaturized liquid chromatography/mass spectrometry for in situ analysis, separation, and detection of biologically relevant classes of