Micro-Thrusters for Satellites

Piezoelectric Actuators in Space Applications

Tech Brief

Larger satellites use micro-thrusters to correct and stabilize their position when operating in the vacuum of space. Typically, they will expel a gas, generating the thrust needed for precise orbital maneuvering and position adjustment.

To achieve the precise motion control required for reliable operation in the unwelcoming environment that is space, micro-thrusters often utilize piezoelectric actuators. These devices help regulate the pressure and the dispensing of the propellant when the satellite has to fine-tune its position.

How are piezoelectric actuators utilized in micro-thrusters?

While micro-thruster design can be based on different operating principles, a commonly used technology is the "cold gas micro-thruster'. In this approach, propulsion is achieved by the expelling of a jet of gas, typically nitrogen, that is stored in a high-pressure tank. As the gas is expelled, a very low (<500µN), but well-controlled force is generated that accelerates the vessel in the opposite direction.

A cold gas micro-thruster usually consists of two sub-systems:
A pressure regulator that ensures accurate control of the propellant pressure in the circuit and a fast and precise valve for dispensing of the propellant. Both functions can be enabled and enhanced by piezoelectric actuators. For redundancy, micro-thruster systems are typically fitted with several piezoelectric actuators and drivers that operate in parallel. The movement of the actuators ensures a fast and precise flow of propellant during operation.

Other applications of piezoelectric actuators in space include photonics and fast piston, tip, tilt steering mechanisms for mirrors.

Which piezo elements are used in satellite micro-thrusters?

For high pressure regulation, piezoelectric multilayer stack actuators are well-suited since high force and high stiffness are desirable traits. Multilayer stack actuators offer high bandwidth and consequently exhibit a short response time. In theory, all geometries can be used, but over time, ring stacks have accumulated space heritage and remain the preferred shape for such applications.

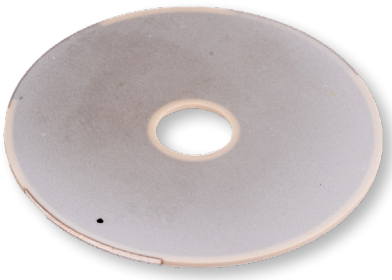
On the low-pressure side, the piezoelectric elements integrated in micro-thrusters are selected on base of their low power requirements, reduced size and mass, high stroke and low force. For such applications, multilayer bending actuators are preferred, as they can provide fast and precise motion in small packages.

Characteristics range of piezoelectric actuators

The characteristics of the two actuators need to be adapted to the specific load and operating conditions of the application in question. The comparison table below is a good illustration of the wide range of characteristics that can be achieved with piezoelectric actuators for micro-thruster applications.

Micro-thrusters enabled or enhanced by piezoelectric actuators are used to adjust satellite positioning.

Example of a multilayer ring stack actuator.



Example of a multilayer ring bender actuator.

Parameter	Unit	Ring Stack	Ring Bender
Product Number	-	NAC2123-H30	NAC2325
Outer Diameter (Ceramic)	mm	12	30
Height or Thickness	mm	30	1.25
Free Displacement	µm	46.2	83.4 up and down
Blocking Force	N	3560	30.4 up and down
Nominal Operating Voltage	V	0-200	0-200
Capacitance	nF	4790	2 x 940
First Mechanical Resonance, Blocked-Free	kHz	20	4.2

CTS custom capabilities

Each company that CTS partners with has unique needs that require custom solutions. Our internal team of engineers and subject matter experts work directly with customers, designing solutions that meet demanding specifications. Typical customization opportunities for piezoelectric multilayer actuators include:

- **UHV Preparation:** Components intended for operation in space typically undergo a specific cleaning process and are packaged individually in sealed bags.
- **Extended Testing and Inspection:** Our capabilities include geometrical measurements, burn-in (AC and DC), additional visual inspection, intermediate checks and additional performance measurements such as frequency response. For space applications, many customers require a batch inspection as well, including destructive physical analysis (DPA).
- **Specific mechanical interface and tighter geometrical tolerances:** A well-defined interface can facilitate the integration of the piezoelectric actuators in a high-precision system.

Piezoelectric expertise

A leading developer and manufacturer of high-performance piezoelectric materials and components, CTS' piezoelectric products come in a variety of compositions, geometries, and dimensions with high quality standards to meet demanding requirements. Our portfolio encompasses bulk and multilayer ceramics, single crystal and printed piezos as well as sub-assemblies, composites, and transducers based on these products.

About CTS

CTS is a leading designer and manufacturer of products that Sense, Connect, and Move. We manufacture sensors, actuators, and electronic components in North America, Europe, and Asia, and provide solutions to OEMs in the aerospace & defense, medical, industrial, communications, information technology and transportation industries.

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