

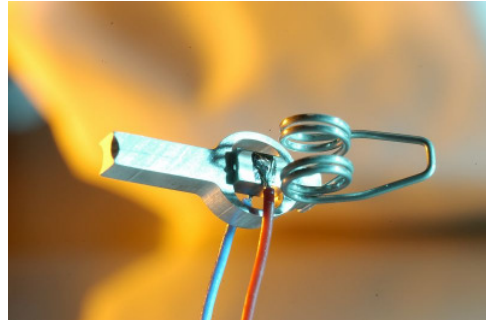
Low Cost Motor Resolves Coating Challenge

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After an introduction of the basic technology of the Elliptec Motor, this article will present the physical analysis necessary for understanding the operation of the motor and will discuss its use in vacuum conditions. The technology can be utilized to address concerns with physical vapor deposition.

At a glance

- Physical characteristics
- Capabilities
- Application in coating process
- Technical specifications



As a result of its low cost and versatility, the Elliptec Motor is suited for use in applications that previously raised concerns such as in vacuum deposition processes used for device coating.

The Elliptec Motor is a versatile, low cost, high precision piezomotor suited for vacuum applications, such as vacuum deposition processes used in the application of coatings. It can be used wherever motions with moderate forces have to be created. Typical applications can be found in direct drives of up to about 0.5 N. Higher forces can also be realized by using simple levers, gear drives, or several Elliptec Motors. The motor can be used for simple applications as well as for very complex motions that require extreme precision, fast reactions, or special capability characteristics. All of this is possible in adverse ambient conditions.

As an actuator based on piezo-technology, the Elliptec Motor delivers forward and backward motion with only a single piezoelectric element and two connecting wires. This advantageous characteristic is achieved by a resonator that has two different resonance frequencies that generate two different driving directions.

Driving Principle

The functional principle of this motor is based on the inverse piezo effect. A micro-controller and two tiny transistors are sufficient to provide the piezo ceramic with the necessary voltage. After application of the voltage, the ceramic expands by less than 1.0 μm , and after switch-off, it contracts again. This alternating cycle occurs approximately 100,000 times per second.

Technical Data

Force	0.2 - 0.4 N (larger forces by way of simple lever mechanisms or by using several motors in parallel)
Blocking Force	~ 1 N
Signal Amplitude (at motor)	5 - 8 V (rectangular), 5 - 10 V (sine-wave)
Supply Voltage (at control electronics)	2.4 - 30 V (requires appropriate power stage)
Current Draw (at control electronics)	1 - 450 mA @ 5 V supply voltage (depends on motor speed)
Weight	1.2 g
Length without Spring	20 mm
Width without Spring	3 mm (8 mm in the area of the piezoelectric element)
Height without Spring	3 mm (4 mm in the area of the piezoelectric element)
Step Size	< 10 μm
Response Time	< 100 μs
Frequency of Operation: Forward	73 - 84 kHz (typ. 79 kHz)
Frequency of Operation: Backward	91 - 108 kHz (typ. 97 kHz)
Service Life [distance]	40000 meters with rotor material PF7595

The motion of the piezo ceramic generates an oscillation of the resonator. The shape of the patented resonator amplifies the oscillations of the piezo ceramic and transforms it into elliptical motions of the resonator tip. A spring pushes that oscillating Elliptec Motor tip onto the element to be driven. The element is moved further by a few micrometers at every oscillation. As a result of periodic repetitions, a homogeneous and continuous motion is generated.

The driving direction depends on the frequency of the applied pulsating voltage. The typical driving frequency is about 80 kHz for the forward and about 100 kHz for the backward direction. This pulsating voltage is typically generated from the digital signal of a micro controller. In contrast to the vast majority of piezo motors due to a multilayer piezo ceramics, a low voltage of 8 V is sufficient to drive the Elliptec Motor. The average step size of one motor step with maximum duty-cycle is approximately 3 µm, resulting in an average running speed of 300 mm/s at 100,000 steps/second. If the motion of the Elliptec Motor is stopped, the motor serves as a brake due to the dynamic friction between the motor tip and the driven element. The friction force depends on the material and is in the range of 0.5 N. At maximum speed, the stopping distance is in the range of about 10 µm to about 100 µm depending on the weight and material of the driven element. The blocking force of the unpowered Elliptec Motor is defined by the static friction between the motor tip and the driven element (material dependent in the range of 1 N).

Vacuum Capability

The Elliptec Motor enables low-cost high-precision motion for vacuum applications. It proved reliable motion under high vacuum conditions ($\sim 10^{-7}$ mBar) with temperatures of up to 95°C and even while depositing a thin film of material in a physical vapor deposition (PVD) process (as long as the deposited material does not noticeably short-circuit the piezo element or change the resonance of the system). The motor only consists of a stainless steel spring (surface area 220 mm²), an aluminium resonator (surface area 335 mm²), and a piezo ceramic (surface area 70 mm²). The driven element can be made from various vacuum compatible materials like ceramics, stainless steel, glass, or plastics. Due to the materials of the motor and the small total surface area with no cavities, the motor shows a very small desorption rate. In addition, it can be baked up to 160°C. Even much higher temperatures can be used if the piezo ceramics is repolarised with a 54 V DC voltage after the baking procedure. The standard PVC-coated cables can be replaced by cables suited for the specific application, such as teflon coated cables. The versatility of the motor allows adapting it for special application purposes with direct drives or with gear trains or levers. Due to the low price for an Elliptec Motor, it is suited for applications where a lot of substrates have to be moved simultaneously. Therefore no complex mechanical systems are required.

Application Example

For physical vapor deposition processes where the substrate has to be uniformly coated from more than one side, the substrate has to be turned. Therefore, the chamber typically has to be vented and the substrate is turned manually in the desired direction. Another (more expensive) possibility is to build a mechanical feed through. For complex substrate surfaces that have to be coated from several sides, a continuous motion is desired. The Elliptec Motor enables continuous motion with variable speeds from several minutes per turn up to several turns per second. In physical vapor deposition processes, the motors typically have to be shielded very well because cleaning (or sandblasting) of the expensive motors is normally impossible. The simplicity of the Elliptec Motor enables reliable motion even under very rugged conditions. If the motor gets coated by diffusing materials in a way that the motor fails, it can simply be replaced by a new one.

Conclusion

The Elliptec Motor enables direct-driven high dynamic motion (rotational or linear) in vacuum with a broad speed range. Its driving principle is based on ultrasonic elliptical vibrations of a small aluminium resonator. A low voltage signal drives the piezo ceramic element. Its simple design without cavities and with a small surface area makes it suited for high vacuum applications even in the rugged environmental conditions in physical vapor deposition processes.

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