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Reciprocating Microtribometer for Testing at Light Loads

SUMMARY

Reciprocating type microtribometer is designed to investigate dynamic friction characteristics of thin films and coatings at light normal loads (50 μN—10 mN) with friction force measurement sensitivity 0.3 μN, sliding speed in the range 0.13 μm/s—10 mm/s and stroke up to 4 mm. Frictionless voice coil motor combined with positioning transducer is used for motion of the plate sample under the ball specimen. Loading is made by electromagnetic system non-sensitive to the topography effect and small tilt angles of the specimen. Friction force is measured by the laser optical system detecting the rotation of the frame suspended on string. The friction force is compensated by electromagnetic system to reduce the influence of suspension system to measurement. Both systems of force measurement and compensation are connected with feedback circuit based on digital signal processor controlled by PC. Friction force and coefficient dependence on a sliding distance is recorded and processed. The data on testing of DLC coatings on silicon substrate were obtained and the workability of the tribometer was found adequate in the specified load-velocity range.

The investigation of friction characteristics of thin films and coatings used in MEMS and similar technology makes necessary some special testing conditions such as light normal loads, low sliding velocity and high sensitivity of friction force measuring systems [1]. It is important that mechanical noise of the motor system must be limited. The loading part of test apparatus must be non-sensitive to the topography and small tilt angles of the specimen to prevent load fluctuation during testing. Presented design of microtribometer being based on sensitive measuring system [2] and frictionless voice-coil motor can solve some of these problems.

The microtribometer consists of the following parts (Fig. 1): base plate and columns mount 1, string suspension 2, voice coil motor 3, sample supporting system 4, electromagnetic loading system 5, laser optical angle measuring system 6, power supply and contol electric circuit 7.

The base plate and columns mount 1 are used as support of the tester parts and electric boards with power supply unit. The string suspension 2 supports the loading system 5. The voice coil motor 3 is used for smooth moving the sample holder 4 during friction tests.The laser system 6 is used for measuring angle position of the loading system which is depends on value of friction force.

The electric circuit 7 based on digital signal processor is used for system control and connected to the PC by COM port. Figure 2 shows the scheme of friction force measurement. When the normal load is applied to the ball specimen the friction force causes rotation of the loading system suspended by vertical string. The laser beam is reflected from the mirror fixed on string suspension. The beam spot position is detected by photo detector. The position sensitive detector and electromagnetic system assembled with string suspension are connected with feedback circuit to compensate the friction force. The feedback system supports the angle position of the loading

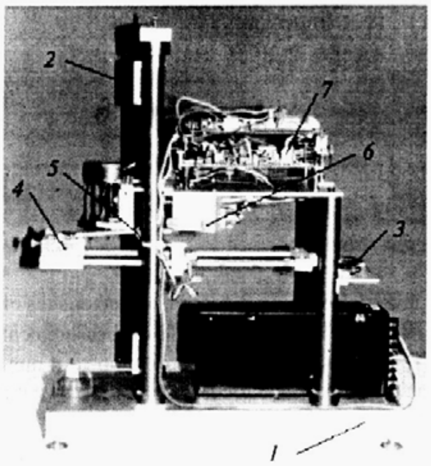

Fig. 1. Microtribometer

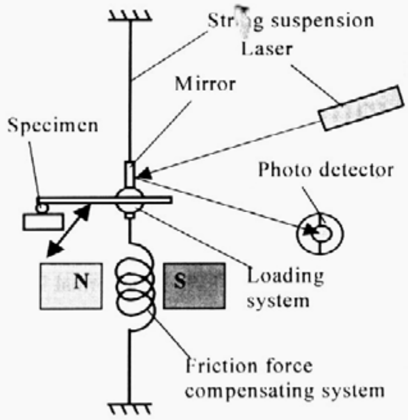

Fig. 2. Scheme of friction force measurement

system to be constant during test. The value of current applied to the winding of electromagnetic system proportional to the value of friction force is recorded and visualized by PC software. The sample is moved by the frictionless voice coil motor without vibrations and mechanical noise in a wide range of speed. The voice coil motor winding and Hall effect position sensor are connected with feedback circuit to control the speed and stroke of motion. Moving parts of the sample holder are suspended by "knife" type support. It can be also substituted by flexible hinge system. The loading system consists of permanent magnet, steel ring, winding, holder of ball specimen and balancing weight. The loading force is are caused by the interaction between electrical current passed through the winding and magnetic field of the permanent magnet. The value of produced force is independent from the angular position of the holder. It means that the value of load of the loading system is independent from the topography effect and small tilt angles of the specimen.
Experimental tests of microtribometer were carried out with 3mm diameter steel ball specimen and DLC coating on a silicon substrate. The device has shown stability of operation and reproducibility of measurement data at specified load-velocity conditions.

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