Sensor for the working surface cleanliness definition in vacuum

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Abstract. Modern development of nanotechnology as one of the modern science priority directions is impossible to imagine without the use of vacuum systems and technologies. And the better the vacuum (lower the pressure), the “cleaner” we get a surface, which is very important for nanotechnology. Determination of the cleanliness of the surface or the amount of molecular layers of adsorbed gases on the working surface of the products especially in industry, where the cleanliness of the working surface is a key parameter of the technological process and has a significant influence on the output parameters of the final product is the main goal of this work.

Modern development of nanotechnology as one of the modern science priority directions is impossible to imagine without the use of vacuum systems and technologies. In vacuum we can deposit thin films, grow crystals for the semiconductor industry, manufacture of microelectromechanical systems (MEMS), investigation of the surface at the atomic level, etc. This is due to the fact that in vacuum we can obtain the atomically clean surface during the entire technological process, i.e. the surface where the amount of adsorbed gases will be negligible compared to atmospheric pressure.

And the better the vacuum (lower the pressure), the “cleaner” we get a surface, which is very important for nanotechnology. To prepare the product for further technological process in vacuum using traditional methods of working surface cleaning, such as the chemical treatment in atmosphere, the plasma dry cleaning, ion beam treatment, heat treatment in vacuum, etc. [1, 2]. However, such methods have their drawbacks and it is impossible to say with certainty that after such cleaning, the surface was “clean”.

So how to determine the cleanliness of the surface or the amount of molecular layers of adsorbed gases on the working surface of the products especially in industry, where the cleanliness of the working surface is a key parameter of the technological process and has a significant influence on the output parameters of the final product? On the one hand is the use of adsorption isotherms. However, such calculations are time consuming and require the development of mathematical models for various modes of operation of the vacuum system [3].

On the other hand is to use the sensor that measures the cleanliness of the working surface of the product in vacuum, developed in Moscow State Technical University jointly with CJSC “AMT”, analogues of which do not exist (figure 1). The main feature of the developed sensor is its versatility, i.e. the possibility of measuring the cleanliness of the working surfaces or amount of molecular layers of adsorbed gases on the surface of the product in the pressure range from $10^5$ to $10^{-10}$ Pa (extremely
high vacuum, XHV), in the temperature range from –40 to +150 °C and in the humidity range from 0.1 to 0.95 RH.

The working principle of the sensor (figure 2) based on the use of breakaway force dependency $F_T$ contact surfaces of the plates (movable, the pressure and fixed plates) of the sensor, simulating the working surface of the test part, from the ratio of the sorbate surface [4].

Investigations of the static friction coefficient in over wide range of vacuum and theoretical calculations showed the possibility of a unified view of the various initial parameters, such as the residual gases pressure, temperature, relative humidity, physical properties of material etc. as the function of the surface coverage [5–10].

The measuring unit of the sensor is located in the working area of the product and determines the breakaway power $F_T$. Further, the measured force value $F_T$ is supplied to the information processing unit, where, taking into account the tracking pressure $F_N$, material properties surface of the test part and the environmental parameters (pressure, temperature, and humidity), calculate the surface plates value according to calibration curve. Sensor features a removable plate, on which is applied a thin material cover identical to the material of the test part. Considering that the measuring unit of the sensor located close to the controlled products, when the sensor is accepted that the amount of
molecular layers of adsorbed gases on the product working surface and on the contacting surfaces of
the sensor plates is equal.

The calculated value of the cleanliness of the product working surface as the amount of molecular
layers of adsorbed gases showed on the information processing display.

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