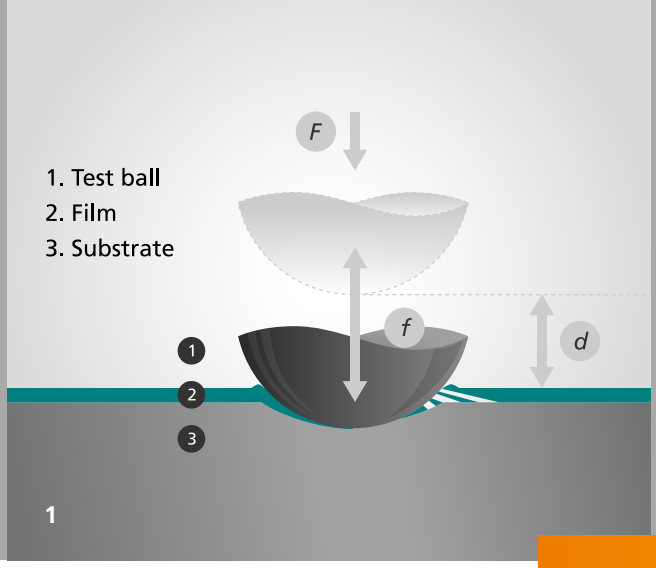


Extract from the annual report 2017
To the website: www.ist.fraunhofer.de/en.html

TESTING THE SERVICE LIFE OF HARD MATERIAL FILMS

In addition to pure static forces, thin PVD and CVD hard material films are also subjected to dynamic forces in many applications. Not infrequently after exceeding a critical alternating stress level they experience a fatigue fracture or other signs of fatigue, such as pitting or near-surface micro-crack formations. In order to approximately predict this situation the susceptibility of a film system can be tested with the aid of the impact test available at Fraunhofer IST. In this regard the resistance of a film-substrate composite is examined for material damage, crack formation, and delamination.

The test principle

The impact test is a dynamic alternating stressing of the film-substrate composite that can be performed on flat components as well as curved components. For this test a fixed, clamped-in test ball exerts a cyclic load on the component to be tested with a frequency [f] of approximately 60 Hz. Depending on the selected operating mode two different dynamic loads can be set. For the first variant, so-called non lift-off operation, the load occurs in continuous contact of ball and component. In this case the distance [d] equals zero (see Fig. 1). The second mode, lift-off operation, is a hammering movement of the ball on the component. In this mode the distance [d] is at least 0.2 mm. Via an electromagnetic drive, test forces [F] between 200 N and 4000 N can be adjusted.

The test balls

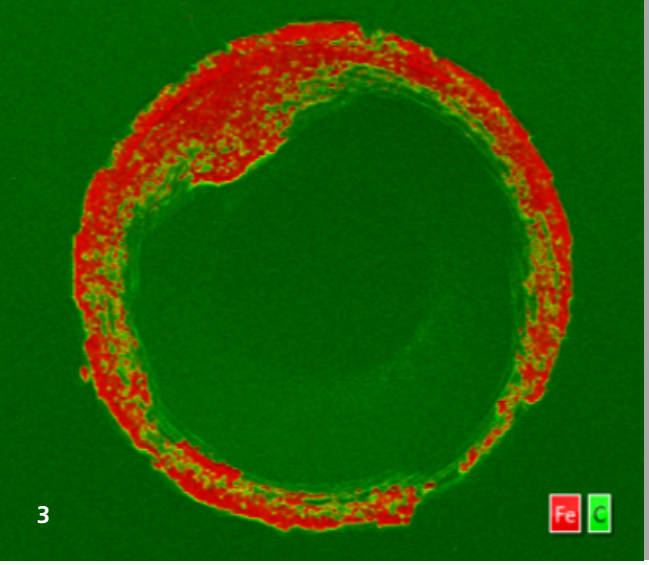
The material and the size of the test balls that are used have an influence on the stresses to the film system. A changed surface pressure occurs depending on the size of the ball. Ceramic test balls are better suited for long test periods > 10^5 impacts and concurrent high loads of ≥ 2000 N, than are steel balls (100Cr6), for example. At these loads, the latter tend to show signs of material fatigue, which usually go hand-in-hand with an irregular material removal on the ball and thus an uneven pressure distribution. Moreover, such a material transfer can make a subsequent EDX analysis more difficult.

First results

The size of the impact impressions, i. e. the diameter and the depth, as well as the so-called pile-up behavior, a bulging in the edge area of the impressions, increases with increasing test force. For example, at a test force of 500 N, a diameter of approximately 450 µm and a depth of approximately 7 µm are determined. On the other hand, at a test force of 4000 N the diameter is approximately 900 µm, and the depth is approximately 50 µm.

Multiple tests, as a rule two or three, are required for an evaluation of layer adhesion. In this regard the interval between the individual tests must be selected in such a manner that the tests do not reciprocally influence each other.

© 2018 Fraunhofer IST | https://www.ist.fraunhofer.de
Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany



1 *Schematic diagram of the impact test.*

2 *Damaged film after the impact test.*

3 *Example of an EDX analysis (green = intact film; red = flaked film).*

Investigation of service life

Due to the recurring load and offload cycles the layer system is subjected to strong stress, which can result in layer flaking and/or expansion cracks in the area of the impact impression. Using optical images or with the aid of REM-EDX photographs the degree of layer system damage can be determined. Figures 2 and 3 show photographs with considerable layer damage. The scope of the defects serves as an indicator for the service life of the film. For very rough surfaces premature layer damage can occur, since high surface pressures occur on the roughness asperities. Moreover, with the aid of a transverse section it is possible to determine the extent to which the substrate underneath the film has been damaged.

CONTACT

Dipl.-Ing. Reinhold Bethke
Phone +49 531 2155-572
reinhold.bethke@ist.fraunhofer.de

© 2018 Fraunhofer IST | https://www.ist.fraunhofer.de
Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany