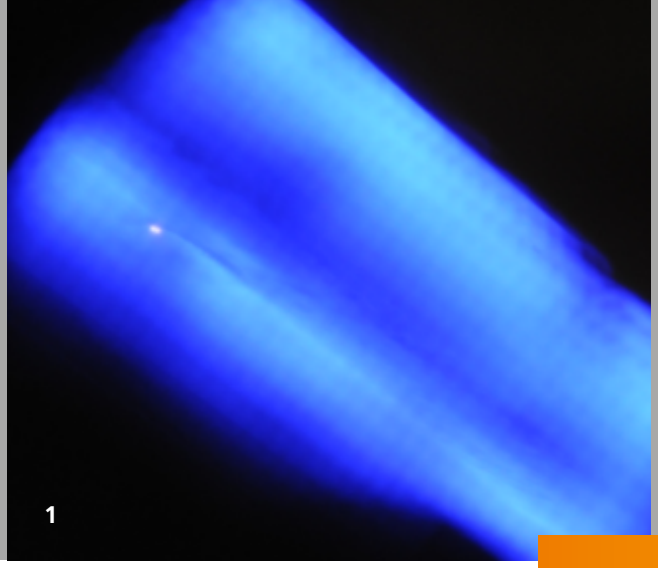

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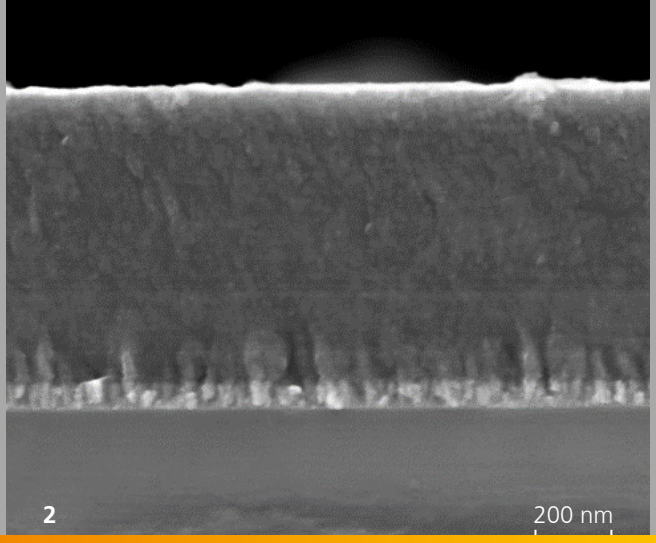

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Extract from the annual report 2017
To the website: www.ist.fraunhofer.de/en.html

HIPIMS-ARC MIXED MODE DEPOSITION OF ta-C FILMS

Diamond-like carbon (DLC) films make an essential contribution towards eliminating friction in a variety of applications. Particularly in the area of mobility fuel consumption, and accordingly CO_2 emissions can be reduced through the use of DLC films. In this area, the hydrogen-free hard DLC films, so-called ta-C films are very popular. Currently these films are almost exclusively manufactured by arc evaporation. At the Fraunhofer IST work is currently underway on an alternative manufacturing method: combined HIPIMS-Arc mixed mode deposition.

The conventional arc process

With the conventional arc process the raw material, carbon, is ionized. The additional energy of the ions ensures extremely high hardness of the deposited films. However due to the process droplets and defects are also generated that can result in rough surfaces and thus render cost-intensive rework of the surface necessary. Alternatively, filtered arc processes can also be used, which induce fewer film defects, but at the same time show a significantly lower deposition rate than the unfiltered processes.

Generation of carbon ions for production of smooth, super-hard films

High Power Impulse Magnetron Sputtering (HIPIMS) is a lower-defect alternative to the arc process. In 2010 [M. Lattemann et al. Diam. Rel Mat. 20 (2010) 68–74] a new variant of the highly-ionized process was introduced, in which the HIPIMS discharge was systematically transitioned into an arc discharge. In a 2015 publication [R. Ganesan et al. J. Appl. Phys. 48 (2015) 442001] for lab scale systems using a round target with a diameter of 7.5 cm, a proportion of over 80 percent of diamond-bonded compounds, so-called sp^3 is reported. The objective of the work conducted at the Fraunhofer IST was to implement a HIPIMS-Arc process in an industrial coating system using cathodes with 600 cm^2 target surface area and a length of approximately 0.5 m (see Fig. 1).

Reproducible adjustment of the ARC transition in the HIPIMS deposition

At the Fraunhofer IST, a HIPIMS generator with peak current of 2000 A was used for the HIPIMS-Arc process. It was possible to successfully define work points at which the continuous HIPIMS discharge is reproducibly transitioned into an arc discharge. The pulse length, the selected working pressure, and the charging voltage of the generator are particularly significant in this regard. The fabricated optical emission spectra prove that in the arc events carbon ions are generated that substantially influence the film growth (see adjacent graphic).

Deposition of ta-C films

After evaluation of the boundary conditions for the systematic transition of the discharge into an arc and verification of the existence of carbon ions, films were deposited for the mechanical characterization. Films with a thickness of up to 2 µm were produced for the investigation. These coatings showed hardness levels of up to 3500 HV (see Fig. 2). It was possible to significantly reduce the defect density and size of the defects as compared to arc films.

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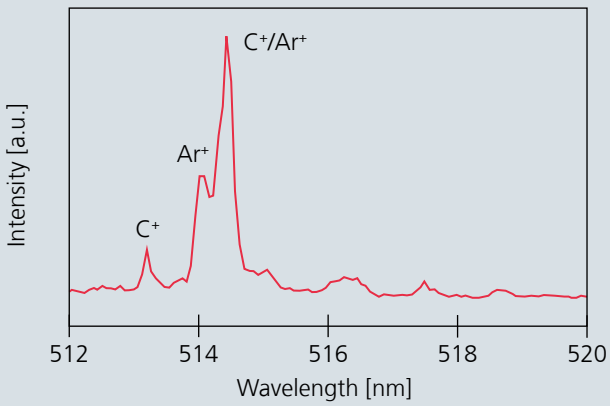
Outlook

Currently work is underway to further optimize the process. The defects should be further reduced or completely eliminated and the hardness should be further increased. In particular for components that cannot be retroactively processed, even at this point the process offers an attractive alternative for a film with smooth ta-C layers.

Temporally integrated optical emission spectrum with carbon ion emission lines of the ionized carbon and argon.



1 *Arc event during the HIPIMS discharge.*

2 *Scanning electron micrograph of the fracture edge of a ta-C film with a hardness of 3500 HV.*

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