BORON-CONTAINING TOOL COATINGS FOR HOT FORMING

In surfaces of tools used for hot forging wear occurs very rapidly due to high process forming forces and high application temperatures above 900 °C. The result is scale on the blanks and thermal shock exposure during the cooling lubrication phase. Recently developed ternary multilayer PACVD coating systems based on alternating material compositions as regards their boron, titanium and nitrogen content reveal some promising approaches for developing wear-reducing tool coatings.

Coating design with graded systems
Ternary systems of the Ti-B-N type have some very interesting structural properties. The PACVD deposition is forming nanocomposites which consist of nanocrystalline fractions of TiN and TiB2 as well as amorphous phases with different proportions of boron. It is now possible in the PACVD coating process to set gradients in the phase distribution as regards the boron and nitrogen contents by varying the process gas exposure. This makes different multilayer systems possible, with designs which differ in their phase composition (proportions of boron) and in the number of layers (right graph).

Application investigations
In collaboration with the Forging department of the IFUM (Institute of Metal Forming and Metal Forming Machines) in Hannover, various boron-containing multilayer designs were compared with references such as plasma- or gas-nitrided equivalents in joint industrial projects. The bolt shape selected for the test tools represents forging dies with extreme contours (Fig. 1). The forming processes carried out in an eccentric press with automated billet handling and cooling lubricant system reproducibly model real forming conditions.

Wear analysis
Analytical investigations of the test tools reveal in the most heavily stressed parts of the bolt significantly different wear patterns for the tested variants also in microsections (Fig. 2). Data for a wear analysis evaluation regarding adhesion (positive values) and abrasion (negative values) have been obtained by using a 3-D coordinate measuring machine to compare the contour after stress to the starting contour (left graph).

Wear analysis of forging processes after 3000 forging operations at 1150 °C.
The measured values show statistical spread typical of forging processes but a clear trend can be seen in the evaluation of the different design variants. In the results, low-boron variants with a high periodicity have the most suitable coating design for this application.

Outlook
The potential of these coating systems for hot-forging applications is currently being tested in industrial trials. Further work will be concerned with combining PACVD coating systems with nitriding treatments in both continuous and also two-step processes. Previous research indicates that the treatment parameters have a considerably influence on the cracking behavior of the tool surface.

<table>
<thead>
<tr>
<th>Coating design of the successfully tested multilayer system Ti-B-N (B’ represents a low-boron standard).</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph showing atomic concentration vs sputter depth" /></td>
</tr>
</tbody>
</table>

1. Coated test tools in the PACVD installation.
2. Nitrided reference tool, wear pattern on the bolts of the test tool after 3000 forging operations at 1150 °C (left), test tool with optimized multilayer system Ti-B-N, wear pattern on the bolts of the test tool after 3000 forging operations at 1150 °C (right).

**CONTACT**
Fraunhofer Institute for Surface Engineering and Thin Films IST
Bienroder Weg 54 E
38108 Braunschweig

Dipl.-Ing. Hanno Paschke
Phone +49 231 844-5453
hanno.paschke@ist.fraunhofer.de