

PO3019

## **Development of PVD-CVD Hybrid Coatings for Thermoforming of Age Hardenable Aluminium Alloys**

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Thermoforming of age-hardenable Aluminum alloys can avoid today's major problems of conventional cold-forming processes, such as inadequate dimensional stability, in particular due to re-deformation from the forming tools geometry. One challenge for a successful application of thermoforming is to restrain the high adhesion affinity of Aluminum, especially at high temperatures.

To establish the thermoforming of age-hardenable Aluminum alloys, the Hessen State Ministry for Higher Education, Research and Arts funds the research cluster ALLEGRO (High Performance Components of Aluminum Alloys by Sustainable and Resource Efficient Technologies). Here, the surface treatment of the hot forming tools by PVD technologies is essential for a successful application of the thermoforming technology.

The use of conventional solid lubricants based on MoS<sub>2</sub> or PTFE counteracts the problem of adhesion tendency in thermoforming of Aluminum, but causes problems in handling and cleaning of the components as well as ecological and health risks due to the misting of the substances. Therefore, surface treatments are necessary to avoid adhesion.

In the present study, a combined PVD and CVD hybrid process is developed. Due to their low adhesion tendency, the coatings should allow a complete elimination of lubricants and release agents.

The focus is on the development of CrAlN coatings, since they have better mechanical properties and higher oxidation stability compared to TiAlN at the typical hot working temperatures. In addition, the modulus of CrAlN-based layers is similar to that of the tool steel substrate, which in particular should prove beneficial under thermomechanical cycling. Also the effect of graded and multilayer coatings with DLC and Si-DLC, respectively, was examined.

The coatings were characterized concerning their microstructural, mechanical and chemical properties. Furthermore, ball on disk wear tests were conducted by reciprocal dry sliding tests by using a SRV 3 high temperature tribometer up to 300°C.

### **Keywords**

PVD

Thermoforming

DLC

CrAlN