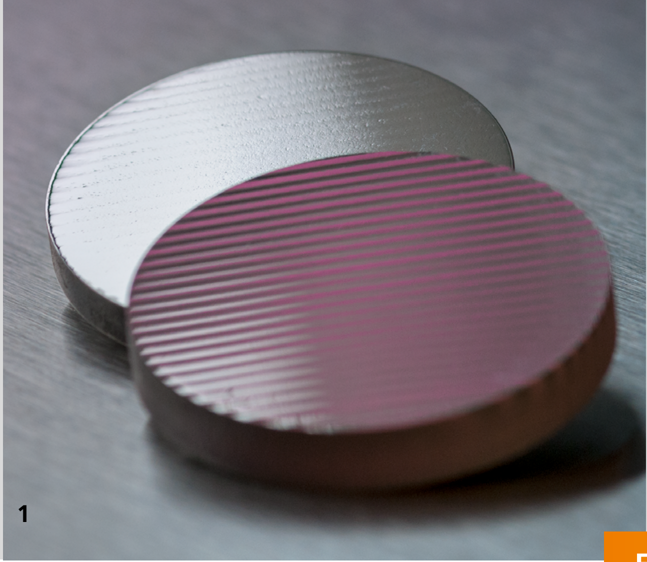

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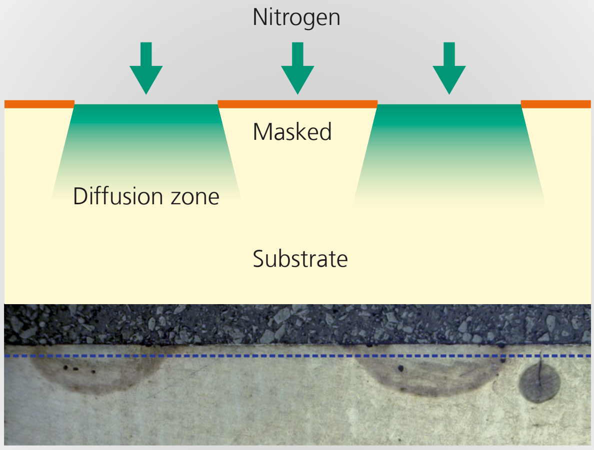

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Extract from the annual report 2018
To the website: www.ist.fraunhofer.de/en.html

THERMAL SHOCK RESISTANT TOOL SURFACES

Forging presents an effective production method for the manufacture of safety-relevant components with outstanding mechanical properties. Their economic efficiency depends directly on tool wear during production which limits the service life of relevant components. Wear is primarily caused by complex interacting mechanical and thermal loads. At the Fraunhofer IST, a number of approaches concerning the improvement of nitriding processes aim at the minimization of wear in different production environments. Particular attention is, thereby, paid to the optimization of tool surfaces which are strained by thermally alternating stress, the so-called thermal shock.

Tool wear through local treatments

The thermal overheating generated through direct contact between the workpiece and the tool during the forming process can cause both a plastic deformation and pronounced abrasive wear.

Through modification of the tool surface and edge zone, e. g. by means of nitriding, it is possible to avoid the thermal softening. The intensive nitriding of surfaces can, however, lead to increased sensitivity for cracking and, therefore, the facilitation of flaking of the material on the treated surface. Current project results, which have already been evaluated in industrial forging applications such as the production of turbine blades or gear wheels, demonstrate the high technological potential of adapted local treatments: By covering specific areas with pastes preventing nitrogen diffusion significant service-life advantages can be achieved.

New approaches for the prevention of crack formation in tool surfaces

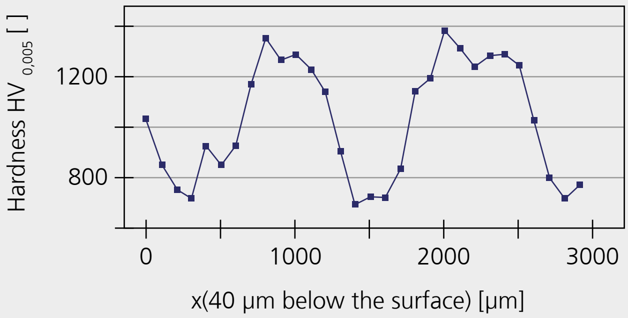
Pastes are used in order to structure material areas in the edge layer zone with adaptable patterns in such a way that ductile zones are created next to nitrided zones (see Figure 1). This way, the formation and propagation of cracks under thermal shock conditions can be prevented. The selection of suitable designs is, however, subject to certain geometric requirements. In addition, industrial suitability must also be taken into account in regards to an automatable, easily reproducible pattern transfer.

Other ways for reducing crack formation under thermal shock conditions result from process combinations of differing diffusion treatments with nitrogen (plasma nitriding, PN) or nitrogen and carbon (plasma nitrocarburizing, PNC) as well as subsequent heat treatments. The latter can be integrated into the vacuum treatment process. However, subsequent treatments performed close to the surface, such as laser-beam treatment or inductive heating, also show promising results regarding a crack-resistant surface.

New possibilities in analytical characterization methods for testing the crack sensitivity of surface zone layers, such as the implementation of the scratch test to evaluate the ductility of the edge zones, have confirmed the developed treatment concepts.

1 *Structured sample.*

2 *Concept of so-called "expansion joint nitriding" with cross section.*



Hardness measurements taken 40 µm below the structured surface demonstrate the effects of the covering: Whilst ductile zones form under the covered and thereby untreated areas, nitrided zones form under free areas with a high hardness.

Evaluation

For the evaluation of the development at laboratory level, a system of test benches is used which represents the production-related thermal shock conditions as realistically as possible. Furthermore, serial forging tests with adapted test geometries for differently exposed die areas and tests in the field of industrial manufacturing demonstrate a high potential for commercial implementation.

Industrial benefits

In addition to the stabilization of the service life and the reduction of specific wear mechanisms through thermal influences, the crack behavior is positively influenced. This leads to a higher efficiency of the industrial production process and enables a more economic production during the forging campaigns of industrial partners.

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