From research

Green-Tools: Cobalt-free carbides with highly efficient CVD diamond and PVD hard coatings for high-performance tools

High-performance tools made from coated carbide play a key role in the German mechanical engineering and the manufacturing industry. Many tools are currently made from tungsten carbide (WC-Co) bonded with cobalt. Both cobalt and tungsten have, however, been listed by the EU as critical raw materials for many years now. In order to address the increasing scarcity of these raw materials and the existing dependence on only a few suppliers and countries of origin, alternative base materials in combination with highly wear-resistant tool coatings have been researched within the "Green-Tools" project.

Indexable inserts with a simple tool geometry for the development of PVD hard coating systems and CVD diamond coatings.

Challenge

High-performance tools are extremely complex and innovative products that are used in the manufacture of almost all technical products. The necessary performance capabilities can only be achieved with "green" technologies if all the competencies involved are optimally coordinated: from the carbide, through the geometry, and on to the appropriate edge-zone and wear-protection coating, as well as the correct processing strategy. For the introduction of new, cobalt-free base materials, the entire process chain of tool manufacturing must therefore be developed and, in particular, precisely matched hard-material and CVD diamond-coating systems and pre-treatments must be researched.

Solution

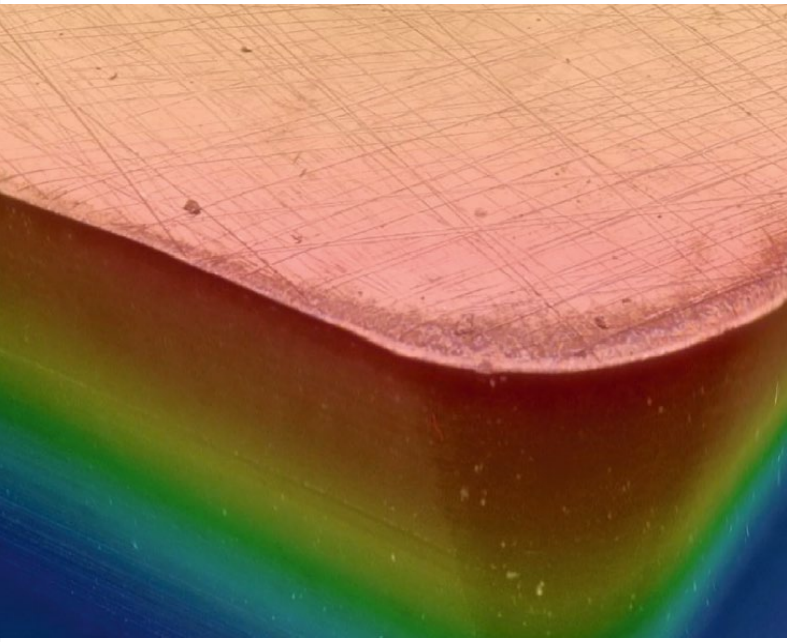
Within the framework of the "Green-Tools" project, the Fraunhofer IST is developing tool-coating systems on the basis of diamond and hard materials for new, cobalt-free carbides with improved composite properties, cutting performance and service life. Our combined process and system expertise is applied here: from tool pre-treatment, through interface design achieved via targeted mechanical and chemical modification of the edge zones - for example with the aid of etching pre-treatments or the application of intermediate layers, and on to the production of innovative diamond and nanostructured hard coatings by means of CVD and PVD processes.

Uses

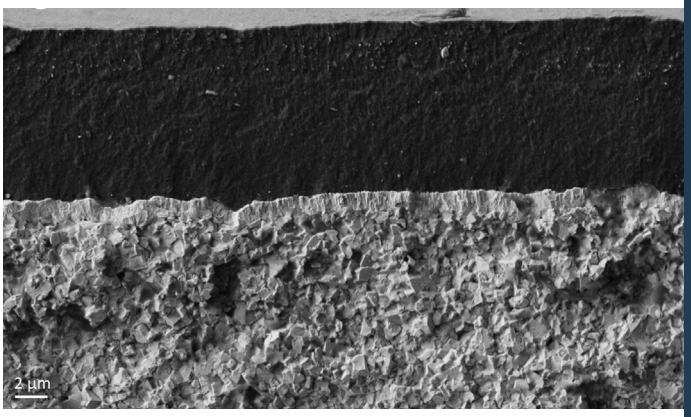
The development of high-performance demonstrators is intended to lower the barrier to market entry, enabling the new technology to be further developed to series maturity with the direct involvement of the key industries of mechanical and plant engineering. As a result, a significant contribution will be made towards the vision of a sustainable and resource-efficient industrial society. The developed pre-treatments and CVD diamond coatings have already enabled a nickel-bonded carbide grade to achieve long tool lives in the turning of aluminum-silicon alloy (AlSi17) that are comparable to the performance of cobalt-containing carbides. By means of a cermet material from the Fraunhofer Institute for Ceramic Technologies and Systems IKTS – which is both Co- and WC-free – in combination with improved hard coatings from the Fraunhofer IST, it was even possible to significantly increase tool life in stainless-steel machining compared with the commercial cobalt-containing reference.

Funding information and collaboration

The results of the "Green-Tools" project were achieved in collaboration with the Fraunhofer Institutes for Ceramic Technologies and Systems IKTS, for Mechanics of Materials IWM, and for Production Systems and Design Technology IPK.



Indexable insert made from alternative base material with an adapted and improved PVD hard coating.



Nanocrystalline CVD diamond coating on a carbide base material. As an alternative to chemical etching treatment, an intermediate layer was applied.

Outlook

The initial results obtained in the coating of cobalt-free base materials with CVD diamond and with nitride hard materials are promising and will be further developed in collaboration with the participating Fraunhofer institutes as well as with partners from industry for specific applications in machining, in particular with regard to the required tool geometries, cutting performance and process reliability. Further target applications, e. g. from forming technology, will also be addressed and materials, treatments and coatings will be researched and optimized for the existing load spetra and application-specific requirements. The aim is to further pursue the developed technology, thereby taking into account raw-material flows during production, recycling and remanufacturing in the context of a closed-loop economy for the sustainable production and industrial utilization of high-performance tools.

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