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# Challenges of Hardness Testing on Ceramic Materials

## Introduction

In industries, such as medical engineering, automotive or electrics, technical ceramics are used in a variety of products and also for coatings of components which have to be highly wear-resistant or temperature-resistant as well as non-conductive or non-corrosive. Beside characteristics like low density or limited thermal dilatation, ceramic materials also show high hardness but low fracture toughness and a high elastic modulus. Due to these mechanical qualities, ceramics are used, for example, in capacitors, isolators, cutting nozzles or blades, bearings, pumps or powder-coated metal surfaces.

Hardness testing is particularly important to prove the mechanical strength of ceramic work pieces which are highly affected by wear; typical examples are friction bearings, brake disks or turbine blades.

Probably the most common hardness testing method for ceramics is the Vickers procedure, usually with low-load test forces; but Knoop is also applicable for hardness tests on ceramic-coated layers due to its little indentation depth and minor crack formation.

## Preparation of ceramic specimens for hardness testing

Optically evaluated test methods like Vickers or Knoop are always very sensitive to the surface preparation quality. In most cases ceramic surfaces do not have a regular structure. Hence, the surface finish quality is very much affected by the crystal size and geometrical deviation of the material. To obtain a surface quality suitable for hardness tests, a finish with lapping or fine polishing is recommended to ensure the

hardness test indents are clearly visible in the ceramic material. Depending on the raw material of a particular ceramic, the surface of the materialorgaphic specimen may appear very dark or even black which makes measurements under a microscope lens difficult.

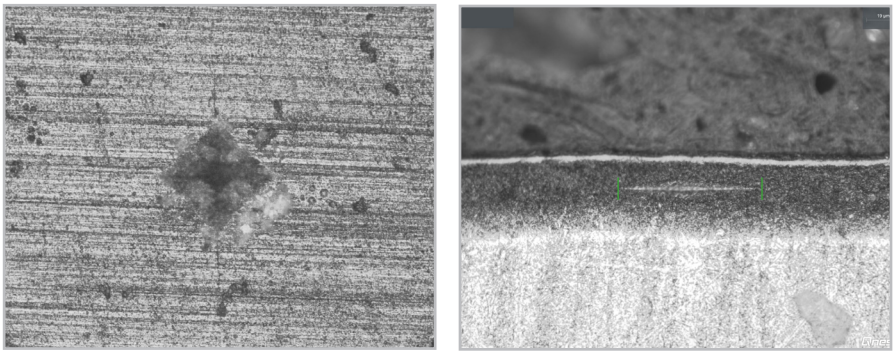

Figure 1
Left: Vickers indent surface of full-ceramic part 10x microscope lens
Right: Knoop indent cross section ceramic layer 40x microscope lens

## Hardness testing procedure and test methods

Vickers and Knoop are the only classic hardness testing procedures also suitable for hard materials >1000 HV like ceramics. Depending on the material composition, ceramics may reach a hardness close to 2000 HV.

**Challenges:**

- Visibility of indents due to the high hardness values
- Visibility of indents due to low test forces (0,3 – 5 kg) and high magnification
- Visibility of indents due to dark surface
- For cross sections: to position the hardness testing indent exactly in the center of the layer

The lower the test force and the lower the surface finish quality, the higher is the probability that the indent diagonals need to be measured manually. Optic evaluation systems delivering good contrasts will enormously increase the level of automation.

## Advantages of the Knoop procedure

With similar load step the indent is smaller and less deep than a Vickers indent, but it is still fairly easy to measure the longer of the two different Knoop diagonals.

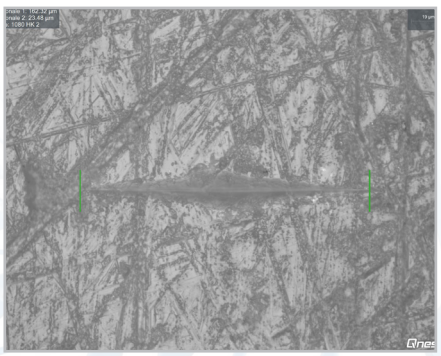

Figure 2
Knoop indent
Surface hardness indent
40x microscope lens

## Conclusion

The advanced optic system quality with QNESS Q10/30/60 and Q150 hardness testers eases daily hardness testing on ceramic material samples or even working with parts with ceramic coatings – depending on the surface finish and magnification automatic image evaluation is even possible in complicated testing situations as appearing when making hardness tests on these complicated materials. Depending on the amount of tested samples either the simple semiautomatic Q10/30/60 "M" variants or the professional fully automated Q10/30/60 or 150 "A" or "A+" variants are the perfect choice for ceramic material testing applications. Reporting tool and export functions enable the creation of test protocols or data export to data management systems.

## QNESS solutions for ceramic materials

**Q10/30/60 Series**

- Test forces between 0.25 g and 62.5 kg (Vickers, Knoop, Brinell)
- Exact positioning
- 6-position measurement turret

**Q150 Series - models Q150A or A+ in production monitoring**

- Test forces between 1 kg and 250 kg (Vickers, Knoop, Rockwell, Brinell)
- Ultra-robust, very compact
- Advanced optic system providing outstanding image quality

Figure 3: QNESS Q10/30/60 (left) and Q150 A and A+ (right) hardness testers