

ASSESSMENT OF MACHINING INDUCED NEAR-SURFACE DAMAGE ON THE BASIS OF X-RAY ELASTIC CONSTANTS

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Abstract

It is well known that voids, pores and cracks affect the elastic properties of materials. These discontinuities do not carry internal or external stresses and thus reduce the macroscopic Young's modulus. This has been proven for porous materials as well as for materials with high crack densities, e.g. thermal barrier coatings. Also for machining induced cracks in brittle materials, particularly mono-crystalline silicon, this has been proven through nano-indentation experiments and laser-acoustic methods.

This paper focuses on the barely investigated influence of mechanical machining procedures on the X-ray constants of elasticity (XEC) of silicon nitride ceramics. The XEC are used to determine (residual) stresses from lattice strains and thus are vitally for a quantitative correct assessment of stress states. In addition, from the comparison of XECs of materials in perfect and damaged conditions, respectively, the amount of damage may be quantified. X-ray measurements of loading stresses are predestined for the assessment of machined near surface regions due to the high surface sensitivity of the method.

The results of our investigations yield an unreckoned high sensibility of the near surface XEC on different machining conditions. Differences in the XECs up to 100% could be determined for common grinding and polishing procedures. From the XEC a quantitative measure for crack sizes and densities could be evaluated using finite-element modelling of cracked surfaces. Additionally performed nano-indentation experiments validate the ranking concerning the machining damage. In conclusion, the experimental determination of near-surface XEC of differently machined ceramics is regarded to be vitally for a quantitatively correct determination of macroscopic stresses and an efficient method to assess the near-surface integrity.