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Young's modulus evolution during sintering of ceramics with and without shrinkage

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Sintering of ceramics consists in the formation of bulk materials from disperse partcicle systems (unconsolidated powder compacts). It always involves strengthening (i.e. due to the formation and growth of sinter necks between the particles or grains) and usually (but not always) also densification (i,e. the reduction of possibly complete elimination of pores) and coarsening (grain growth). During sintering the elastic moduli, e.g. Young's modulus, increase. Using temperature-dependent impulse excitation this has been shown e.g. for alumina ceramics [1], zirconia ceramics [2] and alumina-zirconia composite ceramics [3]. In these cases it is clear that main cause for the increase of Young's modulus during sintering is the densification which leads to a reduction of porosity and is accompanied by shrinkage. This has been extensively investigated via numerical property calculations on computer-generated model microstructures capturing the essential features of partially sintered ceramics [4-8]. On the other hand, more recently it has been shown that even in cases where sintering occurs without shrinkage, i.e. where the porosity remains unchanged, Young's modulus increases during sintering [9]. The reason for this is the aforementioned formation and growth of sinter necks between the particles or grains, together with changes in the surface curvature of the grains, which may be viewed as a kind of naturally occuring microstructural optimization. This contribution gives an overview on the current understanding of the evolution of Young's modulus during sintering with and without shrinkage. It is shown that apart from porosity, three other Minkowski-functional-based microstructural descriptors can be important in determining Young's modulus, viz. the surface density, the mean (Germain) curvature integral density and the total (Gauss) curvature integral density. Of these, the surface density seems to be the most influential parameter. Moreover, from the practical point of view, this microstructural descriptor has the advantage that it need not be determined via image analysis but can be determined via gas adsorption measurements.

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Participation

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