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Microstructural characterization via Minkowski-functional-based global descriptors

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The densities of Minkowski functionals (volume, surface, mean curvature and total curvature) represent a complete set of independent global microstructural descriptors [1-3], as a consequence of Hadwiger's characterization theorem [4]. Similar to correlation functions [5, 6] they offer a systematic and principally automatizable approach for the quantitative description of microstructures, but unlike the latter they form a complete set of simple parameters that are readily determined on real microstructures and, if appropriately implemented into microstructure-property relations, could provide more accurate predictions of effective properties than micromechanical bounds or model predictions based on volume fractions alone. In this contribution we present examples of the application of Minkowski-functional-based global descriptors for the quantitative description of porous ceramics. We show that, apart from the porosity (pore volume fraction) and mean chord length (based on the phase-specific surface density) also a generalized Jeffries size (based on the mean curvature integral density) can be determined from planar sections [1,7,8]. The correlation between these two independent size measures is analyzed and the average pore size thus determined is compared to the characteristic values (quantiles and mean values) extracted from pore size distributions (number- and volume-weighted) determined via microscopic image analysis, after correcting for the random section problem (Wicksell's problem [9]) via appropriate transformation matrices [10]. Moreover, it is shown how the 3D Euler characteristic can be determined on (appropriately binarized) serial sections of spatial images (obtained by X-ray computed tomography).

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