Measurement of Features from Tomographic Images of Materials Structures

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With the fast development of new materials like open and closed foams or fibre reinforced composites there is a growing need for non-destructive testing and microstructure characterization. Computer tomography (µCT) is now able to produce high quality three-dimensional images with a lateral resolution in the range of that of classical light microscopy. Furthermore, modern techniques of processing and analysis of the three-dimensional data sets obtained by µCT opens up new perspectives in materials characterization.

A very attractive set of characteristics which can be computed very efficiently from three-dimensional images are the so called intrinsic volumes (the usual volume \( V \), the surface area \( S \), the integral of Germain’s curvature \( M \), and the integral of the Gaussian curvature \( K \)) and their densities. On the one hand, the intrinsic volumes form a set of geometric characteristics which is in some sense complete (according to Hadwiger’s characterization theorem). On the other hand, there are various relationships between the intrinsic volumes and technological parameters or materials properties.

For fibre reinforced composites, the integral of the mean curvature \( M \) is - up to a multiplicative constant - the total fiber length. Additionally, the transative integral occurring in Crofton’s intersection formula of \( M \) determines the distribution of the fibre directions. Furthermore, integral of the Gaussian curvature \( K \) can be applied to measure the number of cells in open foams or to count the sinter necks between particles of sinter materials in early states of sinter processes. As a further example, the effective conductivity of polycrystals with resistances on the grain boundaries is considered. Under certain weak conditions made for the microstructure, the effective conductivity can be expressed in terms of interface area \( S \) and the distribution of the normal directions of the grain boundaries.