Determining the homogeneity of ceramic structures

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Homogeneity plays an important role in materials science. It is typically used to describe structural characteristics and parameters, such as the distribution or morphology of particles. However, homogeneity is often regarded as a subjective concept, frequently leading to a qualitative assessment that can be misinterpreted or misunderstood. For this reason, Fraunhofer IKTS is researching a suitable method for quantifying the homogeneity of microstructures. The Lorenz curve is a useful way of quantifying homogeneity. This graphical representation enables a clear interpretation of the uniformity of a particular distribution.

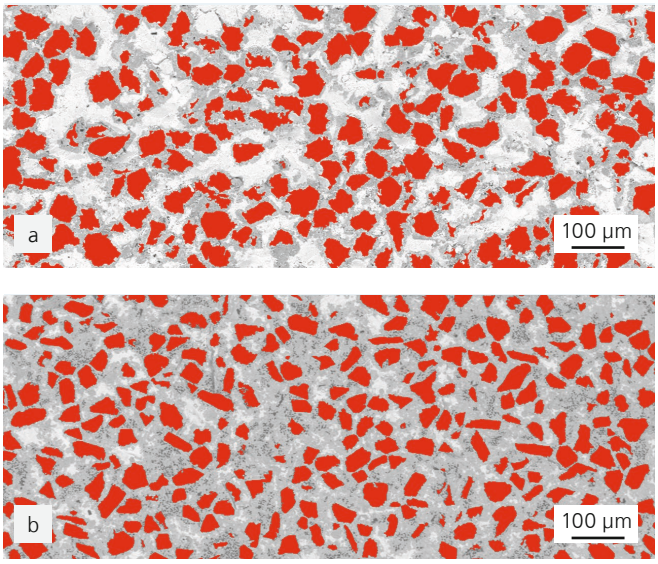

Fig. 1: FESEM images of two diamond-SiC fracture surfaces. Diamond phase (red), a: sample 1, b: sample 2.

Although the concept of homogeneity can be understood in many ways, it was defined by Rossi et al. as follows: "The homogeneity (H) of a system is the similarity of its components considering a given attribute."[1] Complete homogeneity can thus only be achieved if all measured data have the same value.

When analyzing a microstructure, for example, a two-dimensional microscopic image of a material can be defined as a system. In this case, the components could be objects such as particles or pores. Attributes are used to describe the components of a given system. If, for example, particles are detected as components, characteristics such as the particle diameter are a possible attribute. This quantifies the homogeneity as a function of the attribute values. Depending on the analyzed parameters, a distinction is made between the homogeneity of a particle-related attribute and the homogeneity of the distribution of objects. They are referred to as object and region homogeneity, respectively.

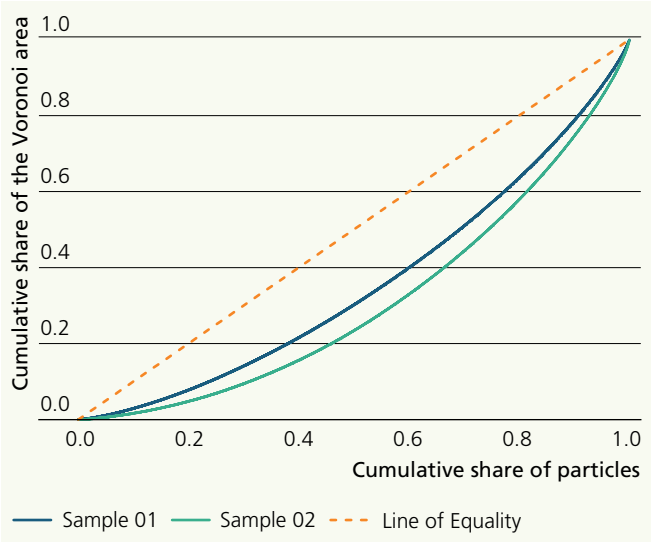

Fig. 2: Lorenz curves of the homogeneity of the Voronoi surface of two diamond-SiC composites.

If the homogeneity of the phase boundary (phase boundary homogeneity) of a structure is of interest, it can also be determined with the aid of measuring fields.

The Voronoi area, i.e. the area that forms from the center point of a grain to the next point, is a suitable attribute for this. A Lorenz curve graphically represents the uniformity of the distribution. Using the example of diamond distribution of two diamond-SiC composites (Fig. 1), the homogeneity can be quantified. It can be observed that the diamonds in sample 1 are more homogeneously distributed than the diamonds in sample 2, because the Lorenz-curve is closer to the Line of Equality, i.e. perfect homogeneity (Fig. 2).

Services offered

- Determination of the homogeneity of ceramic structures using object, area, and phase boundary homogeneity analyses

Literature

[1] P. Rossi, M. Engstler, F. Mücklich (2014): Homogeneity Quantification Method, Practical Metallography.

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