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MACROSCOPIC PROPERTIES OF MODEL DISORDERED MATERIALS

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Disordered materials are ubiqitous in nature and in industry. Soils, sedimentary rocks, wood, bone, polymer composites, foams, catalysts, gels, concretes and ceramics have properties that depend on material structure. Present techniques for predicting properties are limited by the theoretical and computational difficutly of incorporating a realistic description of material structure. For this reason, current models of material properties are largely empirical, without sound theoretical connections to material microstructure. In the absence of any general theory, mechanical properties (elasticity, fracture toughness), and transport properties (thermal and electrical conductivity, permeability and diffusivity) of porous solids are usually correlated to the volume fraction of pore space (porosity) of the solid by the form:

$$\frac{\sigma}{\sigma_s} = C\phi^n = C(\frac{\rho}{\rho_s})^n. \quad (1)$$

Here σ is the physical property (thermal or electrical conductivity, elasticity, fracture toughness, diffusivity, permeability), ϕ is the porosity or volume fraction of the cellular solid, ρ is the density and the subscript s designates a property of the solid material. Most experimental and theoretical work has been devoted to establishing the phenomenological correlation coefficients n and C for different classes of material.

A general model for microstructure was recently proposed by Berk [*Berk, Phys.Rev.A*, 44 *5069 (1991)*]. The model is based on level cuts of a Gaussian random field with arbitrary spectral density. The freedom in specifying the parameters of the model allows the modeling of physical materials with diverse morphological characteristics. We have shown that the model qualitatively accounts for the principal features of a wider variety of disordered materials including geologic media, membranes, polymer blends, ceramics and foams. Correlation functions are derived for the model microstructure. From this characterisation we derive mechanical and conductive properties of the materials. Excellent agreement with experimentally measured properties of disordered solids is obtained. The agreement provides a strong hint that it is now possible to correlate effective physical properties of porous solids to microstructure. Simple extensions to modelling properties of non-porous multicomponent blends; metal alloys, ceramics, metal/matrix and polymer composites are also discussed.

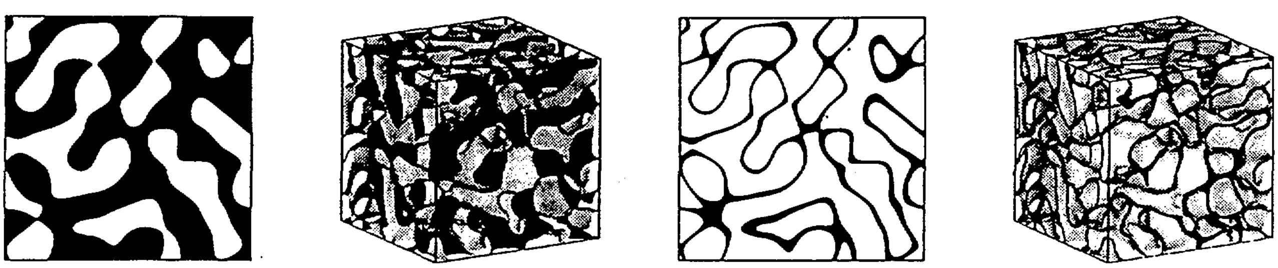

Figure 1: *Examples of two model morphologies given by the level-cut model: Figures show both a two-dimensional cut and the three-dimensional Image.*