Abstract

Fitting the dc conductivity and first order ac conductivity results of continuum percolation media, using percolation theory and a single phenomenological equation.

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In the last 30–40 years the most widely used and probably successful approach in the modeling of experimental results for the dc and first order ac conductivity (dielectric constant) results of good conductor-bad conductor (Metal-Insulator) media, near the second order Metal-Insulator Transition at the critical volume fraction, has been percolation theory. Recent experiments will be presented that will show that the standard percolation equations (which are actually power laws with an unspecified constant) and a phenomenological equation, which has the same parameters as the percolation equations, are both able to quantitatively fit dc and first order experimental results, as a function of volume fraction and frequency, for continuum percolation media. However, only the analytical phenomenological equation, which has the same parameters as the percolation equations and reduces to them in the ideal cases, is able to fit the results for all frequencies and volume fractions, as well as the second order ac results. It can also be used to generate scaling functions for the dc results, as a function of the ratio of the conductivity of the two components and the volume fraction, as well as the first order terms of the ac conductivity as a function of frequency and volume fraction.

The major problem, with even the very accurately fitted results, is that the exponents s, t, $u(x)$ and $v(y)$ can sometimes, but not always, be described using existing theories. Also, in many instances, there is no theory which relates s, t, u and v. This applies to results fitted both to the original percolation equations or the new phenomenological equation. Reasons why previous theories for the exponents in granular systems, those most often measured, and the relations between them are inadequate will be advanced.

These experiments, for the first time, show that the exponent s is not the same for the dc conductivity and the ac dielectric constant below the critical volume fraction. These measurements also show that the dielectric exponent s is a function of frequency.

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