Abstract

The Correct Modeling of the Second Order Terms of the Complex ac Conductivity Results for Continuum Percolation Media, Using a Single Phenomenological Equation

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Received: Fri, 1 Feb 2002 08:38:01

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) are unable to, in some cases not even qualitatively, model the second order terms of the complex ac conductivity of continuum percolation composites. It will then is shown that a phenomenological equation, which has the same parameters as the percolation equations and reduces to them in some ideal cases, can usually accurately but always qualitatively, fit all the experimental results (first and second order) as a function of volume fraction and frequency. The second order terms are the dielectric loss (conductivity) below the critical volume fraction and a hump, as seen in water-oil emulsions, in the real dielectric constant, which often peaks beyond the critical volume fraction. New results show that $1/f$ noise, just above the critical volume fraction, is characterized by two exponents, and not one as has previously been observed. A qualitative model for this behaviour in granular conductor–insulator media is presented. This model helps explain the difficulty in the exact modeling of the conductivity results, just above the critical volume fraction, near the percolation threshold in granular systems.

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