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Scaling description of non-ohmic direct current conduction in disordered systems

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ABSTRACT

Complex charge transport mechanisms in disordered systems are often difficult to characterize owing to a dearth of suitable probes. Non-Ohmic response to an applied electric field is however a common uniformity which spans across all disordered systems. Static disorder can be of various types so could be the mechanisms causing non-Ohmic response due to the intricate relationship of electric field response to the intrinsic disorder configuration of the material. In this review article, the electrical transport properties of several disordered systems including composites, amorphous/doped semiconductors, conducting polymers and manganites (both in single crystal and poly-crystalline phase) are highlighted from the standpoint of non-Ohmic direct current conduction. This non-Ohmic conduction is characterized by a single voltage scale known as the onset voltage which scales with the Ohmic conductance (i.e., disorder) with an exponent. The universality of this exponent and the scaling description of similar variation of the conductivity with field in different disordered systems are reviewed in detail. A comparison of experimental data in various disordered systems with the existing theoretical models available in the literature is also included. We hope that the universality of the electrical response of electrical transport across a plethora disordered systems will spur theoretical efforts for developing a microscopic theory to understand the scaling behaviour.

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Contents

Nomenclature

Abbreviations

AF	Antiferromagnetic
AH	Apsley and Hughes
AC	Alternating Current
a-Ge	Amorphous Germanium
a-C	Amorphous Carbon
AFCOI	Antiferromagnetic Charge Ordered Insulating
BCMO	$Bi_{1-x}Ca_xMnO_3$
BCSMO	$Bi_{0.4}Ca_{0.4}Sr_{0.2}MnO_3$