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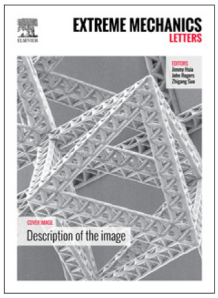

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Stress-dependent electrical transport and its universal scaling in granular materials

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Abstract

We experimentally and numerically examine stress-dependent electrical transport in granular materials to elucidate the origins of their universal electrical response. The dielectric responses of granular systems under varied compressive loadings consistently exhibit a transition from a resistive plateau at low frequencies to a state of nearly constant loss at high frequencies. By using characteristic frequencies corresponding to the onset of conductance dispersion and measured direct-current resistance as scaling parameters to normalize the measured impedance, results of the spectra under different stress states collapse onto a single master curve, revealing well-defined stress-independent universality. In order to model this electrical transport, a contact network is constructed on the basis of prescribed packing structures, which is then used to establish a resistor-capacitor network by considering interactions between individual particles. In this model the frequency-dependent network response meaningfully reproduces the experimentally observed master curve exhibited by granular materials under various normal stress levels indicating this universal scaling behaviour is found to be governed by i) interfacial properties between grains and ii) the network configuration. The findings suggest the necessity of considering contact morphologies and packing structures in modelling electrical responses using network-based approaches.

Keywords: RC network, contact mechanics, granular materials, electrical transport, universal scaling.