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Metal oxide/porous silicon nanocomposites for variable resistance devices

JEREMY MARES, Vanderbilt University

Variable resistance electronic components have recently experienced growing interest owing to applications such as ReRAM technologies, memristor-based neuromorphic architectures and artificial neural networks. Such devices are typically nanometer-scale in size and require either high-resolution lithography or very refined thin-film growth techniques to realize devices with observably variable conductivity. Here, we present an elegant and economical method for achieving macroscopic (i.e., mm- or cm-scale) continuous-state variable conductivity devices using a metal oxide/porous silicon nanocomposite. We present the first observation of variable resistance in such nanocomposites (described colloquially as "memristance"), and a mathematical model for the observed behavior is proposed which explains the time-varying, field-dependent conductivity modulation based on ionic defect migration in the metal oxide nanocrystallites. The variable conductivity phenomena observed are also shown to depend on the composition of the films. The model shows excellent agreement with experimental data and allows for estimation of ionic defect mobilities. Multicycle nonvolatility in the devices is shown to be on the order of 1000 s.