Memristor: modulating resistance via electron-ion interactions*

Yogesh N. Joglekar

Department of Physics

Indiana University – Purdue University Indianapolis

Abstract

Memristor – a resistor with memory – is a long-postulated but recently discovered new circuit element that complements the three well-known circuit elements, namely a resistor, a capacitor, and an inductor. It was experimentally realized in a titanium oxide thin film doped with oxygen vacancies. The resistance of a memristor, and memristive system in general, depends on the electrical charge that has flown through it and not just on the voltage applied to it. We use a non-linear, asymmetric drift model to describe the motion of dopant ions that, in turn, determines the effective resistance of the memristor. This interplay between ionic and electronic transport provides a natural mechanism for memory and switching behavior. We obtain the electrical properties of basic memristive circuits, and show that they exhibit non-exponential current and charge decay, negative differential conductance, and frequency-dependent hysteresis in the current-voltage characteristics. We then present a Lagrangian approach to describe the dynamics of memristive systems and its implications to quantum effects in memristors and other memory elements such as mem-capacitors and mem-inductors.

* “The elusive memristor: properties of basic electrical circuits”, Y.N. Joglekar and S.J. Wolf**, Eur. J. Phys. **30** (2009) 661-675.
** Undergraduate student (UROP Summer Fellow 2008).