THE DESIRED MEMRISTOR FOR CIRCUIT DESIGNERS

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Memristors hold promise for use in diverse applications such as memory, logic, analog circuits, and neuromorphic systems. Different applications require different characteristics from the memristor. Understanding the desired characteristics for different applications can therefore assist device physicists in targeting the required behavior when fabricating memristive devices, potentially optimizing these devices for different applications. In this presentation, the desired characteristics for different applications are discussed from the viewpoint of the electronic circuit design process.

Logic and memory are digital applications, in which the resistance of the memristor typically represents a binary value. A low resistance is typically considered as a 'logical one' and a high resistance is treated as a 'logical zero'. In these applications, memristors can be employed for computation and control, as well as data storage. In memory applications, it is also possible to write more than one bit into a single memristor if the resistance of the device is quantized to multiple levels. In these applications, the difference among different data must be carefully determined. It is desirable to provide a non-destructive read mechanism, but read operations may induce drift in the stored state. The device design process therefore should consider the tradeoff between speed and robustness due to this state drift phenomenon. A preferred memristor would therefore be highly nonlinear, with a well defined and abrupt threshold between the two distinct states.

In applications using analog circuits and neuromorphic systems, however, the resistance typically requires a continuous value. Memristors can be used as configurable devices where the resistance of the device is initialized by a specific procedure, separate from typical circuit operation; during regular circuit operation, the memristor behaves as a simple resistor. In these applications, it is desirable for the memristor to behave as a nonlinear nondestructive device, similar to the read mechanism in digital applications. In neural networks, memristors mimic the role of synapses, such that each device may interact with other devices throughout the operation of the circuit.

Memristors can also be used as computational elements in analog circuits, such as analog counters. In these circuits, it is desirable for the memristor to maintain a linear behavior, where the local current changes the resistance of the memristor.

Several additional characteristics are also important and are discussed in this presentation: low power consumption, good scalability, long data retention, high endurance, and manufacturing and voltage compatibility with conventional CMOS.