The Desired Memristor for Circuit Designers

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Many Options for Memristive Devices

- Resistive switches
- STT MRAM
- PCM
- CBRAM
- etc.
Different Applications Require Different Memristors

- Memristor-based Memory
- Logic gates from memristors
- Analog circuits
- Neuromorphic systems
- More?
What is the required memristor for circuit design?
General Model – TEAM
ThrEshold Adaptive Memristor

- Tunable nonlinearity
- Current threshold

\[
\frac{dx(t)}{dt} = \begin{cases} 
  k_{off} \cdot \left( \frac{i(t)}{i_{off}} \right)^{\alpha_{off}} \cdot f_{off}(x), & 0 < i_{off} < i \\
  0, & i_{on} < i < i_{off} \\
  k_{on} \cdot \left( \frac{i(t)}{i_{on}} \right)^{\alpha_{on}} \cdot f_{on}(x), & i < i_{on} < 0, 
\end{cases}
\]

Desired Properties Shared by All Applications
Relative Priority Depends on Application

- Low power consumption
- Good scalability
- Speed
- Long data retention
- High endurance
- Manufacturing compatibility with CMOS
- Voltage compatibility with CMOS
Memristors at Every Level of the Memory Hierarchy
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New memory use for memristors?
Store Digital Data with Memristors

- Logical value as resistance
- Multi level memory
- Distinct values – high $R_{\text{off}}/R_{\text{on}}$ ratio
Non-Destructive Read Mechanism

- State drift phenomenon
- Need for highly nonlinear behavior
- Ideally: voltage/current threshold
Memristors as Logical Elements

• Different families of memristor-based logic gates:
  – IMPLY
  – MRL (Memristor Ratioed Logic)
  – MAGIC (Memristor Aided Logic)
  – PLA

Desired Properties for Memristor as Logic Element

• In addition to memory properties, depends on logic family:
  – MRL – linear memristor
  – IMPLY, PLA – nonlinear memristor
Conclusion: Different Application - Different Memristor

**Linear**
- MRL
- Multilevel memory
- Memory
- PLA
- IMPLY

**Nonlinear**

- Power
- Size
- Data retention
- CMOS compatibility
- Speed
- Endurance
Discussion

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http://memristor.shorturl.com/