Hardware implementation of Artificial Intelligence with memristors

The first implementation of the memristor as a simple two-terminal electron device in 2008 by the Stanley Williams group at HP opened a great deal of opportunities in many areas: non-volatile memory, in-memory computing, secure systems, reconfigurable electronics and, above all, neuromorphic computing.

The memristor is a passive device predicted by Prof. Leon Chua at Berkeley University in 1971 using symmetry arguments. Although initially conceived as a device linking charge and magnetic flux, it is more useful to consider it as a resistance with memory of its past electrical activity.

Big arrays of memristors are already commercialized by several companies as a replacement of flash non-volatile memories and as a storage class memory. A relevant example is the 3D Xpoint memory developed by Intel and Micron using the combination of Phase-Change Memory cell and an Ovonic Threshold Switch acting as a selector.

Being a resistance whose value can be changed by electrical signals, memristors have been shown to act as electronic synapses. This allows using them to fabricate Artificial Neural Networks (ANN) by combining synapses organized in crossbar arrays (even in 3D) and CMOS neurons. Resistive RAM memristors can be fabricated in the back-end of the line of the CMOS process (also easily stackable in 3D by using several metallization layers) and hence can be easily combined with conventional CMOS circuits.

In this session, we will review the state of the art of memristors applied to neuromorphic circuits that implement ANNs. It will be shown how these neuromorphic circuits open new perspectives for the implementation of AI in highly-efficient, secure, and reliable deep-learning ICs. This innovative chips will be suitable for portable, wearable, distributed, secure, and trustful AI applications which nicely fit the present requirements of the IoT.

Papers are solicited reporting recent results but also state-of-the art review and future views of neuromorphic circuit applications. Subjects relevant to this session are:

- fabrication, characterization and modelling of memristors for neuromorphics
- neuromorphic circuits
- implementation, modelling and characterization of electronic synapses based on memristors
- electronic implementation of neurons
- learning algorithms for neuromorphic circuits
- in-memory computing based on memristor arrays
- memristor-based computing
- secure systems based on memristors
- AI applications implemented in hardware with CMOS and memristors.