Can Materials be Intelligent, to Code and Process Information?

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Semiconducting materials are the building blocks in computers as switching and logic components. The size of the transistors, the smallest logic devices, is central to computers; the smaller the size, the more transistors can fit on a chip, and the faster and more energy efficient is the processor. The IC technology, currently reaching 10-nm level, has been so far governed by the Moore's Law, i.e., number of transistors on a chip doubling every two years until now. Recent advent of Artificial Intelligence (AI), block chain and gaming applications, however, boosted the requirement of processing speed with respect to power consumption, especially since 2014. In most of these applications, the CPU and GPU workloads are related to the computational complexity of coding and processing of the data patterns due to the **sequential** architecture and the algorithms.

Besides high performance switching characteristics, materials have other key properties that would allow restructuring the computational architectures beyond the current limitations. Intelligent systems in nature are morphologically adaptive, **parallel** in real time and highly energy efficient. Entropy-energy relationship is the main driving factor of biological intelligent systems including the Human Brain. Each dendritic input of a neuron in nature has a unique pattern recognition capability while their topological interconnection is a result of separate adaptation process, a hierarchical architecture not yet mimicked in conventional artificial neural networks (ANN). In our research we aim to develop both the software and hardware mimicking brain-like information processing architectures. We determined, e.g., that minimum energy dissipation-maximum entropy derives morphological circuit remodeling of bio-nano components, thereby demonstrating the response of conformational structures similar to those in nature. Conformational characteristics of biomolecules, e.g., proteins, with respect to external fields, driven by probabilistic distribution of applied signals and peripheral bias, can provide alternative development ways for directly coding and processing information *in organico* instead of digital processing *in silico*. Also, the reverse approach to convolutional energy-entropy derived mapping of material properties can also help rapid data driven design of bio/nano hybrid systems for specific target functions by using deep learning AI solutions on the existing computer platforms.