Abstract for Public

Design of Functional Organic Memristors (DOOM)

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In our modern life computers play a crucial role. They not only perform complicated computations in scientific labs and control robots in our industries, but also almost every single device in our home is equipped with a small computer. Our cellphones, cars, home and kitchen appliances, and smart watches are all equipped with processors. Events like COVID-19 pandemic pushed us into our homes and now we are even more aware of our need to online communications. But a serious issue regarding our computerized life is that our computers' appetite for energy is increasing much faster than the capacity of our energy production. In fact, by putting fossil fuels and nuclear power plants away to keep our environment clean, we have very limited capacity to produce cheap energy. A report published by Semiconductor Industry Association (SIA) in 2015 had warned giants of computer industry to lower energy cost of computations because if global energy demand for computations keep increasing with their current rate, no later than 2040 we will face an energy crisis; our energy demand for computation alone will surpass the energy production capacity in the whole world!

To solve this issue there is a competition to introduce new ways of computation. One efficient way is called in-memory processing. This technique eliminates data transfer between memory (RAM and Hard disk) and the processors (CPU and GPU) by doing the process right in the memory. This approach has two main advantages:

1. Energy dissipation in terms of heat as a result of electric resistance in wires will be eliminated. This part is in fact the largest source of energy loss in computers.
2. The process will be considerably faster as there is no need to exchange data between a separated memory and a processor.

To achieve this goal computer industry needs a device that is called "memristor". Memristors have been known since 2008 but so far, they have not found their niche in the industry because they are either very expensive or the cheap ones have not been as efficient as they need to be. My goal is to change the game by introducing novel families of memristors that unlike old-fashioned silicon-based devices are designed having biological systems in mind. I propose devices that resemble amino acids, the building blocks of living organisms. The goal of my proposal is to design and finetune the structure of artificial amino acid-based memristors. These systems will benefit from several advantageous over silicon-based systems:

1. They are cheap and easy to fabricate because they do not contain expensive and rare metals.
2. They are flexible and compatible with body therefore, they can be used in body-computer interfaces that are necessary for controlling some vital processes, like controllers of heartbeat in people with arrythmia or brain-body interfaces for paralyzed people.
3. Unlike silicon-based devices, they are easy to degrade and do not pollute the environment.
4. Last but not the least, they can solve the energy crisis waiting for us in near future in 2040 and bring opportunities for the country to lead production of novel devices for computers.