Project: **Smart Materials for Next Generation Energy-Efficient Neuromorphic Computing**

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Description: Nowadays, artificial intelligence (AI) finds countless socioeconomic applications in Canadians' everyday life, for financial forecasting, data mining, intelligent camera security and facial recognition, and monitoring environment biosphere processes, to only list a few examples. While AI technology already displays impressive cognitive capabilities for pattern recognition, its energy requirements are orders of magnitude higher than those of the human brain for similar operations. This in turn results in a very high carbon footprint. This drawback could be overcome by completely redesigning computer architecture to make it similar to that of the brain. A human brain's ability to learn occurs through its neural network, which is composed of neurons interconnected by synapses. Learning is done through a change in the synapse conductivity, referred to as synaptic weight. This phenomenon can be directly reproduced in ferroelectric materials, where polarization can be modified by applying external voltage. This change in polarization can be exploited to directly induce a change in the material's conductivity, therefore directly mimicking a change in synaptic weight. Yet, ferroelectric materials still need to be optimized to be exploited in the next generation of computers and AI technology.

In this project, students will synthesize ferroelectric materials (namely $Hf_{0.5}Zr_{0.5}O_2$ and $Al_{1-x}Sc_xN$) by radio-frequency magnetron sputtering. They will then characterize the materials using atomic force microscopy, piezoresponse force microscopy, and X-ray diffraction. Their goal will be to optimize the deposition parameters to obtain ferroelectricity in the materials. The materials will then be fabricated into artificial synapses and their ability to learn will be assessed through spike-timing-dependent plasticity measurements.