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Tunable high-entropy hopping conductors for neuromorphic computing

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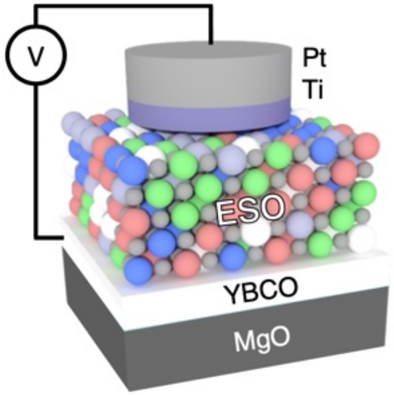
Memristor arrays are a promising platform for machine learning. Traditional amorphous oxide-based memristor materials, however, suffer from device stochasticity and a lack of tunability which hinder applications requiring adaptive networks. IRG2 researchers have demonstrated tunable carrier transport in single crystalline (MgCoNiCuZn)O entropy-stabilized oxide thin films, where tunability stems from formulation-engineered point defects that trap charge with predictable energy barriers for activation.

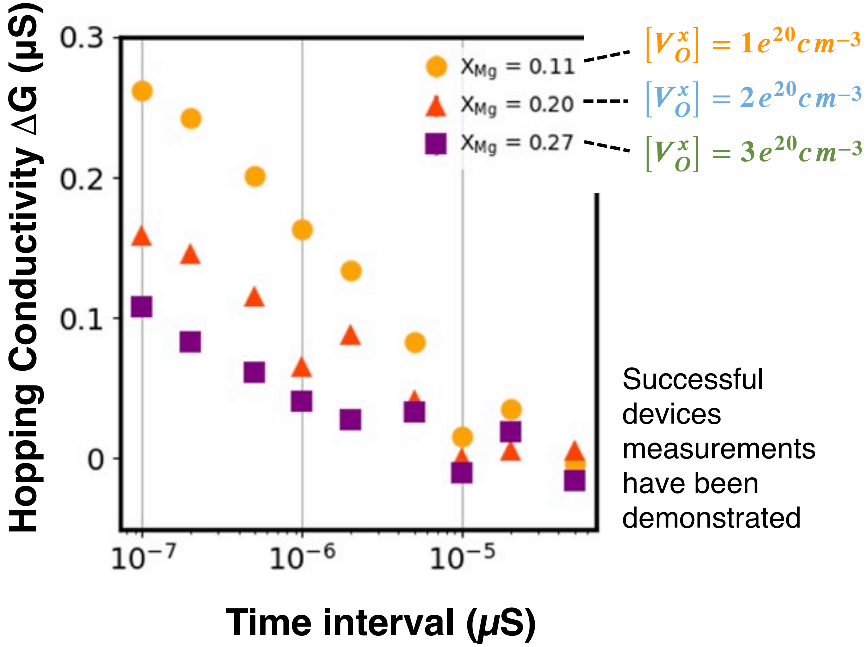
This entropy-stabilized material undergoes composition-tunable hopping conduction in agreement with composition-dependent point defect formation and electronic structure from first-principles calculations. Pulsed measurements reveal a low resistance state with a short, composition-tunable retention time that can be harnessed for memristor function. The precise tunability of carrier transport makes this material an excellent candidate for neural network systems with record energy efficiency for temporal data processing.



$Mg_{0.11}Cu_{0.29}(Ni,Co,Zn)_{0.2}O$

$Mg_{0.20}Cu_{0.20}(Ni,Co,Zn)_{0.2}O$

$Mg_{0.27}Cu_{0.13}(Ni,Co,Zn)_{0.2}O$



Successful devices measurements have been demonstrated

Left: Schematic of high-entropy parallel plate memristor device with three different formulations that vary the Mg:Cu ratio, which in turn determines the conduction barriers and relaxation times.

Right: Hopping conductivity and carrier density of memristors with these formulations showing transport tunability for energy efficient processing.