Conduction Mechanisms in $CsPbBr_3$ Resistive Randon Access Memory

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The rapid growth of IoT and AI applications requires next-generation memory devices with high storage capacity, low power consumption, and fast switching speeds[1]. Among emerging candidates, resistive random-access memory (ReRAM) is particularly promising due to its simple metal-insulator-metal structure, low operating voltage, and suitability for in-memory and neuromorphic computing[1]. All-inorganic halide perovskites are promising for resistive ReRAM because of their low-temperature solution processability and environmental stability. Their mixed ionic-electronic transport can support low-voltage, nonvolatile switching[1]. However, the conduction mechanism in $CsPbBr_3$(CPB)-based devices is still under discussion and requires more detailed analysis. Here, we investigate the conduction mechanism in cross-point CPB ReRAM devices by means of temperature-dependent electrical analysis of both the high-resistance state (HRS) and the low-resistance state (LRS). The devices consist of a Ni bottom electrode, a 50 μm×50 μm CPB switching layer fabricated by top-down patterning[2], and an Al top electrode, as shown in Fig. 1a. The transport regime was analyzed by using the log$I$-log$V$ characteristics shown in Fig. 1b. At a low bias (<0.35 V), the current is nearly Ohmic over the full temperature range. Between 200 and 250 K, segments with 1 < slope < 2 indicate partial thermal trap occupation prior to injection, followed by a trap-filling regime as the bias increases. At 300 K, a short trap-free space-charge-limited conduction (SCLC) region with a slope of about 2 is observed immediately before SET, which is consistent with thermally and field-assisted trap prefilling[3]. At 350 K, the HRS remains nearly Ohmic up to SET, indicating that thermally prefilled traps suppress a distinct SCLC region and cause trap filling to merge with the switching event. Furthermore, the LRS conduction was studied by temperature-dependent low-bias (0.01 V) resistance measurements, as shown in Fig. 1c. The resistance remains nearly constant at approximately 47 Ω up to 150 K and then increases linearly from 200 to 350 K. This behavior is consistent with metallic-like conduction and can be described by $R(T) = R_0[1 + \alpha(T - T_0)]$. From the linear fit above 150 K, a temperature coefficient of resistance of $\alpha \approx 0.004\ \mathrm{K}^{-1}$ is extracted, which is close to the reported value for Al[4]. This work demonstrates that charge transport in CPB ReRAM devices is thermally activated and field assisted in the HRS, whereas the LRS is dominated by metallic-like conduction, consistent with the formation of an Al-based conductive filament. These results provide a physical picture of resistive switching in all-inorganic perovskite memories and are relevant for the design of reliable perovskite-based ReRAM and possible neuromorphic devices.

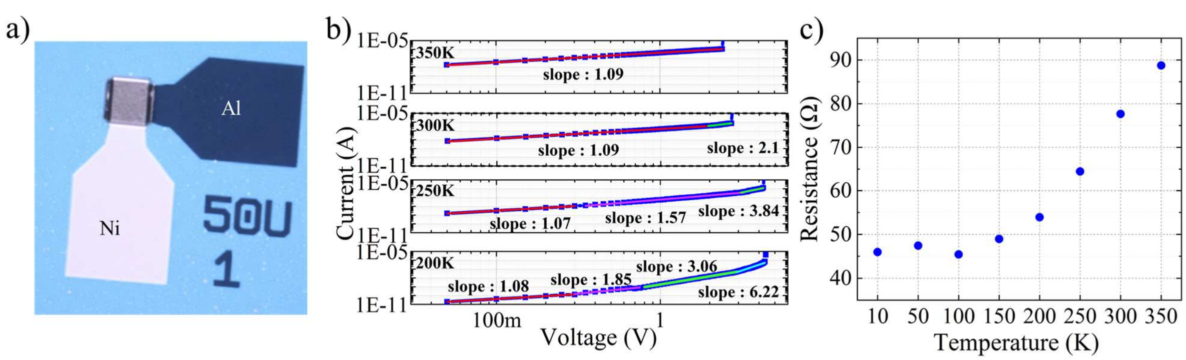

Figure 1. Ni/CPB/Al: (a) Device microscopy image, (b) Temperature-dependent log$I$-log$V$ characteristics in the HRS, and c) LRS resistance as a function of temperature.

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