Electrical Characterization and Line-Array Operation of PCM Devices in Bridge Geometry

J. Zhao[(1)], K. Schnieders[(1)], A. Espiari[(1)], A. R. Jalil[(1)], S. Wiefels[(1)]

[(1)] Peter-Grünberg-Institut, Forschungszentrum Jülich GmbH, Jülich, 52425, Germany

The rapid growth of artificial intelligence has intensified the demand for energy-efficient computing architectures. To overcome the von Neumann bottleneck and improve energy efficiency, Compute-in-Memory (CIM) architectures have emerged as a major research focus. Phase-change memory (PCM) has emerged as a promising solution for addressing key challenges related to power efficiency, scalability and operational latency in CIM and neuromorphic architectures [1]. However, reliable device initialization, switching operation, and state stability remain critical challenges for practical array-level implementations [2].

This study investigates the switching behavior of PCM devices using a set of tailored measurement algorithms developed to enable reliable switching and precise characterization during SET/RESET operations. Devices based on AIST (Al– and In–doped Sb_2Te) and GST (Ge–Sb–Te) compositions with varied geometries are characterized, revealing material- and geometry-dependent switching performance. AIST devices exhibit more stable switching behavior, whereas GST devices provide a larger operating window and show the potential for improved endurance under high-voltage programming conditions.

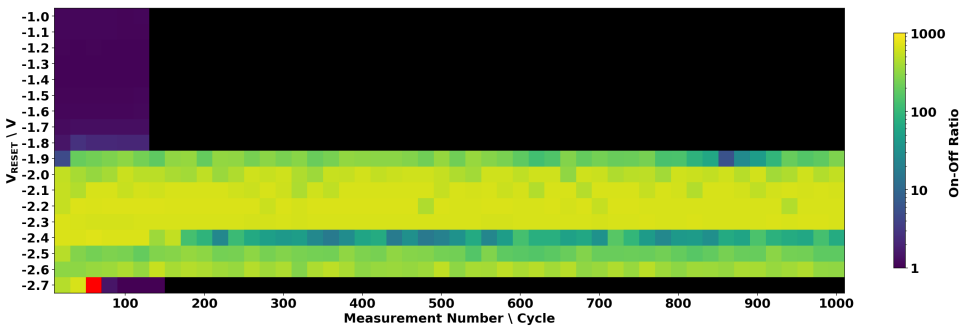

Figure 1: Cycling performance of a single AIST device presented as on–off ratio. The device geometry is 200 nm × 200 nm × 25 nm.

Building on single-cell measurements, the performance of a PCM-based line array is evaluated. A statistical simulation model is parameterized with measured resistance distributions and drift profiles, allowing array-level behavior to be assessed under realistic operating conditions. The simulations reveal key limitations arising from state drift and device-to-device variability, particularly in the low-resistance state.

These findings highlight critical factors affecting array-level reliability and provide valuable insights into the scalability and robustness of PCM-based memory architectures, offering practical guidance for future implementations in high-density CIM systems.

[1] G. S. Syed et al., Chem. Rev., 125(11), 5163–5194, 2025.

[2] S. Raoux et al., IBM J. Res. Dev., 52(4–5), 465–479, 2008.