Defect-Engineered TiS_2 for Memristive Switching in 2D Memory Devices

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Two-dimensional (2D) transition metal dichalcogenides (TMDs) have garnered attention for emerging memory and neuromorphic computing applications. [1] Among them, TiS_2 is particularly attractive due to its intrinsic metallic conductivity, even under partial oxidation, and its tunable electronic properties via defect engineering. [2,3] Unlike semiconducting TMDs such as MoS_2, which typically experience performance degradation with defect introduction, TiS_2 retains high conductivity (222 mS/cm at room temperature) and structural stability, making it well-suited for resistive switching applications.[4,5] These features are critical for memristors, which require stable conductive paths, fast switching, and reproducible hysteresis. [6] In this study, we propose to employ proton irradiation to introduce sulfur vacancies in few-layer TiS_2, enabling controlled defect engineering. These vacancies generate tunable trap states and conductive pathways while preserving lattice stability. By adjusting defect location and density, we aim to achieve consistent memristive behavior with energy-efficient switching and strong data retention. [7] Preliminary electrical measurements, supported by Raman and XPS analysis, show high channel conductance and sweep-rate-dependent hysteresis, indicating the presence of intrinsic defects. These findings underscore the potential of TiS_2 as a defect-tolerant 2D platform for next-generation memory devices.

1. Kwon, K. C., et al. *Nano-Micro Letters*, 14(1) (2022)
2. Ke Chen, et al. *Appl. Phys. Lett.* 116, 121901 (2020)
3. Tingting Liu, et al. *Nano Energy*, Volume 67, 104295 (2020)
4. Ansh, A., *et al. Commun Mater* **4**, 8 (2023)
5. Kim, J. Y., *et al. Energy Storage Materials*, 41, 289–296. (2021)
6. Qin, F., *et al. Materials Advances,* 4(8), 1850–1875. (2023)
7. Rajput, M., *et al. Commun Mater* **5**, 190 (2024)