Microfluidic DNA Data Storage Architecture with Multiplexed Random Access and Dynamic File Management

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The exponential generation of digital information is rapidly outpacing the capacity of silicon-based information storage systems, paving the way for development of alternative information storage materials. DNA has emerged as a promising alternative for archival data storage, offering higher information storage density, long-term stability, and minimal energy requirements. However, realizing DNA data storage as an industrially viable technology remains a challenge due to several limitations such as higher latency of writing and reading, limited file management, and higher synthesis-associated costs. Microfluidics enables precise manipulation of liquids and (bio)chemical reactions, making it ideal for applications in DNA data storage. We introduce a microfluidic DNA data storage architecture that enables physical separation of DNA files into discrete storage chambers, allowing a direct file selection of file of interest rather than relying on sequence-based retrieval. By leveraging multilayer soft lithography enabled combinatorial multiplexing for reconfigurability of fluid routing, we streamline and demonstrate automated file operations such as file retrieval, merging, and deletion, providing a programmable workflow for dynamic information storage.