

ABSTRACT

A three-dimensional (3D) nonvolatile memory device includes a cell string. The cell string includes a pillar structure comprising a ground selection transistor, a plurality of memory cells, and a string selection transistor stacked vertically over a substrate. The memory cells comprise a first cell group and a second cell group stacked on the first cell group, and a horizontal width of at least a portion of the pillar structure decreases in a depth direction towards the substrate. A method of programming the memory device includes initializing a channel of a memory cell of the first cell group of the cell string through the ground selection transistor of the pillar structure, and then applying a program voltage to the memory cell of the pillar structure of the cell string.

FIG. 1