The Phase-Change Memory with a Separate-Heater Layer Design For The Multilevel Storage Device

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CHE NORZAKIMAN BIN CHE AHMAD
FACULTY OF ELECTRICAL ENGINEERING UNIVERSITI TEKNOLOGI MARA (UiTM) 40450 SHAH ALAM
MALAYSIA

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Che Nor Zakiman Bin Che Ahmad
Faculty of Electrical Engineering
Universiti Teknologi MARA (UiTM)
40450 Shah Alam
Selangor Darul Ehsan

ABSTRACT

A phase-change memory structure with a separate heater layer was proposed to enable crystallization process for multilevel storage. This is to overcome the problem faced by the conventional design which is the difficulties to control the crystallization process in order to achieve the multilevel storage. A finite element analysis was conducted to investigate the possibility of multilevel storage using COMSOL 4.4 Multiphysics software. A 100ns SET pulses with an increasing amplitude from 0.1V to 0.7V were applied for heating the memory layer, which is $Ge_2Se_2T_5$ (GST). The transition from the amorphous to the crystalline phases induced by heating the material above its crystallization temperature (450K-900K) and switching back to the amorphous state is realized by melting and quenching the material. The result is the proposed design shows more data to be stored in order to achieve the multilevel storage than the conventional design of phase-change memory with a 50nm thickness of memory layer (GST) and the 500nm width of the structure itself.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The phase-change memory (PCM) is the new technology of nonvolatile memory instead of the flash memory that we are currently using now [1-3]. The phase-change memory has many advantages over the flash memory. For instance, it has fast switching speed, good data retention, high endurance, low programmable energy, excellent scalability and improved compatibility with complementary metal oxide semiconductor (CMOS) [4].

The Germanium-antimony-tellurium or GST (GeSbTe) is a phase change material from the chalcogenide glasses group that possesses highly different electrical resistivities depending on its phases. The resistance will be high in amorphous state while it will be low in crystalline states [5-6]. The GST currently is used in rewritable optical discs and also the phase-change memory applications. Its recrystallization time is about 20 nanoseconds that allowing bitrates of up to 35 Mbit per second to be written and direct overwrite capability up to 10,000,000 cycles. The new phase-change memories are possible using n-doped GeSbTe semiconductor with the melting point of the alloy is about 600 degree C and the crystallization temperature is between 100 and 150 degree C which is 450K to 900K.