CLAIMS

1. A phase change memory (PCM) structure configured for performing a gradual reset operation, the PCM structure comprising:

first and second electrodes;

a phase change material layer disposed between the first and second electrodes;

a thermal insulation layer disposed on at least sidewalls of the first and second electrodes and phase change material layer, the thermal insulation layer being configured to provide non-uniform heating of the phase change material layer;

a substrate, wherein the first and second electrodes are disposed on an upper surface of the substrate and spaced laterally from one another, the phase change material layer is disposed on the upper surface of the substrate between the first and second electrodes and on an upper surface of the first and second electrodes, and the thermal insulation layer is disposed on a portion of the upper surface of the substrate and on an upper surface of the phase change material layer to thereby encapsulate the first and second electrodes and phase change material layer; and

a dielectric cap layer formed over the upper surface and sidewalls of the phase change material layer, wherein the thermal insulation layer is formed as an air gap and disposed between the dielectric cap layer and the phase change material layer.

2. The PCM structure of claim 1, wherein at least one of the first and second electrodes comprises a material having a thermal conductance of less than 100 watts per meter-kelvin.

3. The PCM structure of claim 1, wherein the PCM structure has a substantially rectangular form factor.

4. The PCM structure of claim 1, further comprising a channel formed in the upper surface of the phase change material layer between the first and second electrodes.

5. The PCM structure of claim 4, wherein the upper surface of the phase change material layer has a stepped profile.

6. The PCM structure of claim 1, wherein the PCM structure is configured to have a length in a range from 5 nm to 50 nm, and have a width in a range from 100 nm to 1 μm, wherein a ratio of width-to-length of the PCM structure is 20:1.

7. The PCM structure of claim 1, wherein a thickness of a combined thermal insulation layer and substrate is in a range from 30 nm to 300 nm.

8. The PCM structure of claim 1, wherein a cross-sectional thickness of the phase change material layer is in a range from 20 nm to 200 nm.

9. The PCM structure of claim 1, wherein the first and second electrodes are laterally separated and are substantially in a same plane relative to one another.

10. The PCM structure of claim 1, responsive to a bias signal being applied between the first and second electrodes, an induced current flows laterally through the phase change material layer.

11. The PCM structure of claim 1, wherein the substrate comprises a material having a thermal conductivity of less than 0.1 watts per meter-kelvin.

12. The PCM structure of claim 1, wherein applying a first reset pulse between the first and second electrodes, the first reset pulse having an amplitude that is greater than a crystalline phase change material switching threshold voltage and less than an amorphous phase change material switching threshold voltage, for a prescribed duration causes a temperature of the phase change material layer to rise until a temperature in a center portion of the phase change material layer exceeds a phase change material melting temperature, wherein the center portion of the phase change material layer switches to a high-resistance amorphous state, wherein applying at least one subsequent reset pulse between the first and second electrodes, the at least one subsequent reset pulse having an amplitude and duration that is the same as the first reset pulse, causes a temperature of the phase change material layer to rise until a temperature in a portion of the phase change material layer adjacent to the center portion exceeds a phase change material melting temperature, wherein the portion of the phase change material layer adjacent to the center portion switches to a high-resistance amorphous state while the center portion of the phase change material layer remains in the high-resistance amorphous state.