

# Atomic layer deposition of GeTe

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## ABSTRACT

GeTe thin films were deposited by Atomic Layer Deposition (ALD). The process was studied in detail to confirm characteristic ALD behavior. Film compositions were analyzed with energy dispersive x-ray analysis. Phase change properties of the films were studied using high-temperature x-ray diffraction, resistivity measurements and a static laser tester. The crystallization properties of ALD GeTe were found to be similar to those of sputtered films.

**Keywords:** atomic layer deposition, phase change material, GeTe

## 1. INTRODUCTION

Phase change memories are considered as a potential solution for the future non-volatile memories. A material that would enable stability at higher temperatures, low power consumption and fast writing is required. Ge<sub>2</sub>Sb<sub>2</sub>Te<sub>5</sub> (GST) has been the center of many research efforts, but other materials such as GeTe are gaining interest. GeTe has been proven to crystallize fast<sup>1</sup> and as a very thin film<sup>2</sup>.

With decreasing device dimensions and three-dimensional structures, conformal processes are required. Atomic layer deposition answers this with a self-limiting growth mechanism that leads to excellent step coverage<sup>3</sup>. Previously the binary processes for GeTe and Sb<sub>2</sub>Te<sub>3</sub> have been combined to form GST<sup>4,5</sup>, with a composition tuning option of adding elemental Sb cycles to the deposition<sup>6</sup>. Binary materials such as GeTe are much easier to control and integrate into devices.

## 2. EXPERIMENTS

GeTe films were deposited in an ALD reactor from GeCl<sub>2</sub> · (C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>) and (Et<sub>3</sub>Si)<sub>2</sub>Te. The films were deposited at various substrate temperatures, starting from 90 °C. Precursor pulse lengths were varied. The linearity of film thickness with cycle number was examined. The composition, growth rate, crystallinity and phase change properties of the thin films were analyzed.

## 3. RESULTS & DISCUSSION

ALD GeTe films were of good quality and mirror-like. The growth rate of GeTe is heavily dependent on the deposition temperature, and decreases with increasing deposition temperature. There is no detectable growth at 150 °C or higher. The film thickness grows fairly linearly with an increasing number of deposition cycles, and can be easily controlled by the number of deposition cycles as is typical for ALD. At 90 °C, the saturative growth behavior typical of ALD is evident.

The conformality of the GeTe films is excellent, which is to be expected from ALD. GeTe can be deposited into deep trenches with the film uniformly coating all surfaces. The films were slightly Ge rich (54% Ge and 46% Te), but with a very low impurity content for low deposition temperatures.

All films were amorphous as-deposited, but crystallized into the rhombohedral phase at 165 °C according to high-temperature x-ray diffraction measurements (Fig. 1). At around 385 °C, a transformation to the high temperature cubic phase could be seen.

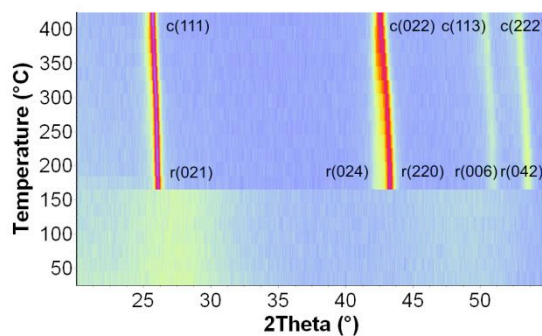


Figure 1: HTXRD of a GeTe film deposited at 90 °C.

Reds and yellows indicate higher intensities.

Crystallization times of as-deposited ALD GeTe are comparable to those of sputtered films, according to laser studies. In comparison, the recrystallization of melt-quenched films occurs faster than in sputtered films. Resistivity difference between amorphous and crystalline films is several orders of magnitude.

#### 4. CONCLUSION

GeTe films deposited by ALD are conformal and stoichiometric. They also have the required crystallization properties and a good contrast between amorphous and crystalline phases.

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#### Biography

Tiina Sarnet received her M.Sc. in inorganic chemistry at the University of Helsinki in 2010, where she is currently working towards her Ph.D. Her main research fields include atomic layer deposition of phase change materials and process development.