Characterization of Phase Change Material (PCM) to TiW electrode contacts

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Phase change memory concept is based on the switching of a small volume of chalcogenide material from the crystalline (low ohmic, SET) state to the amorphous (high ohmic, RESET) state and vice versa [1]. This is done by localized heating by the application of an electrical pulse (Joule heating). The memory cell consists of a selection transistor and a (phase change) resistor. SET, RESET and read out are done by the same transistor using different pulses. In the case of RESET, power has to be dissipated in the crystalline phase to melt the material. The power in this pulse has to be delivered by the connected transistor. For optimum power transfer the resistance of the crystalline part of the memory cell (to be amorphized) and the impedance of the transistor has to be the same. The total resistance, however, includes the contact resistance of the phase change material to the electrodes. Characterization of the contacts between phase change material and the resistance of the PCM are important for optimizing the switching behavior of the memory cells.

In this work the electrical contact resistance of both $Ge_2Sb_2Te_5$ (225) and doped-Sb_2Te alloy to commonly used $Ti_{30}W_{70}$ electrode material has been measured using four terminal Cross Bridge Kelvin Resistor (CBKR) structures. The specific contact resistance could be accurately extracted from electrical measurements on these structures. Apart from the CBKR structures, four point Van der Pauw structures were used to measure the sheet resistance of the phase change and electrode material, respectively. In the experimental set up measurements were done at annealing temperatures from 250°C – 400°C in N_2 ambient resembling IC process temperatures.

Figure 1 shows the change in the sheet resistance of PCM's under study for the different annealing temperatures. The sheet resistance of 225 and doped-Sb_2Te decreases by 53% and 32%, respectively. The reduction of the sheet resistance of doped Sb_2Te is due to the evolution of the structure in the alloy (XRD measurements). The sheet resistance of TiW remains constant over the annealing temperature range. The measured resistance of the CBKR structure is the sum of the real contact resistance and the parasitic resistance contribution of the PCM and TiW at the contact. A decrease in sheet resistance of the PCM with annealing (Fig. 1) decreases the parasitic PCM resistance contribution at the contact. Using the 2D CBKR model from Saraswat [2] this parasitic resistance can be taken out and the real specific contact resistance can be extracted. Figure 2 shows the specific contact resistance values for the two PCM's to TiW for the different annealing temperatures. The specific contact resistance of 225 to TiW remains constant with the annealing temperature, whereas the values for doped Sb_2Te decrease by an order of magnitude. It is concluded that, unlike 225, the doped Sb_2Te interacts with the TiW electrode material upon annealing. The contact resistance and the sheet resistance after the IC process determine the switching behavior of embedded the memory cells.

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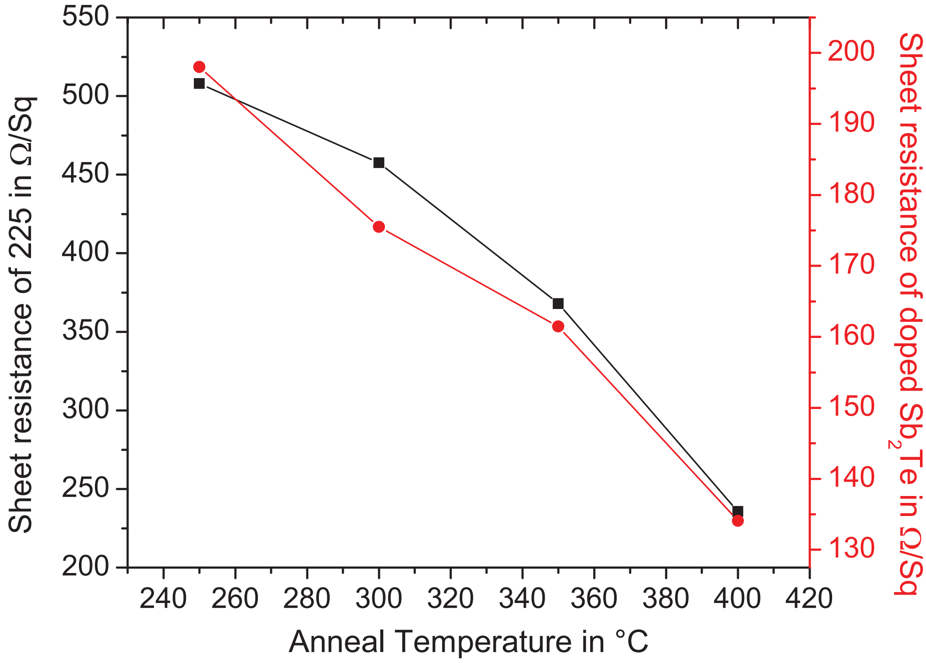

Figure 1: Change in the sheet resistance measured for 225 and doped-Sb_2Te at room temperature with annealing temperatures from 250°C to400°C.

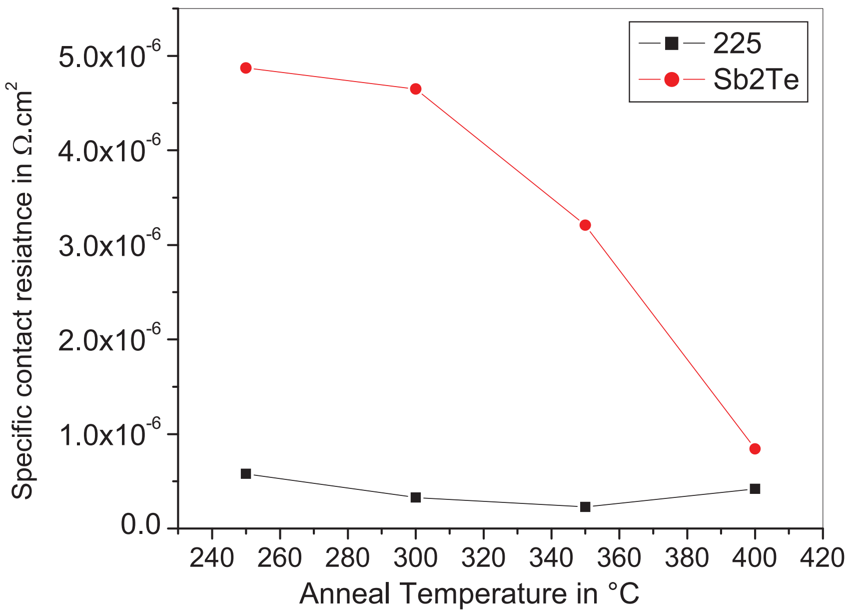

Figure 2: Change the extracted specific contact resistance measured for 225 and doped-Sb_2Te to TiW with annealing temperatures from 250°C to400°C.

[1] M. H. R. Lankhorst, B. W. S. M. M. Ketelaars, and R. A. M. Wolters, "*Low-cost and nanoscale non-volatile memory concept for future silicon chips*", Nature Materials. Vol- 4, 2005, pp.347.
[2] T.A. Schreyer, K.C. Saraswat, "*A two dimensional analytical model of the cross bridge Kelvin resistor*", IEEE Electron Device letters, Vol-7, 1986, pp.661.