cleaned glass substrates at room temperature (300°K). An evaporation rate of 4 Å sec^{-1} was maintained to produce films of SnO_2 with approximately uniform thickness of about 1300 Å. The thickness of the films was measured during evaporation by a quartz crystal thickness monitor and also by the interferometry method.

2.2 *Resistivity measurement*

The resistivity of the films was measured in a furnace during annealing as a function of time. The temperature of the furnace was maintained constant (± 5°C). The sheet resistivity of SnO_2 films was also measured during annealing as a function of temperature in the range (623–808 K). The temperature of the furnace was regulated at approximately 3°C/min. The temperature was measured with a chromel-alumel thermocouple. X-ray diffraction measurements of the films were made (Philips x-ray diffractometer, model No. PW-1140/90) and scanning electron micrographs taken (SEM-501, Philips make).

3. Results and discussion

The sheet resistivity of the as-deposited SnO_2 films was very high (> 20 MΩ) and decreased with annealing in air. The variation of sheet resistivity as a function of time during isothermal annealing at different temperatures is shown in figure 1. The as-deposited or unannealed SnO_2 films (evaporation temperature above 1800°C) are expected to be amorphous in character as shown by its high resistivity. This amorphous character is confirmed by x-ray diffractometric characterisation (figure 2a). The peaks of the x-ray diffraction pattern show crystallization with time during annealing at 717, 701 and 688 K respectively (figure 2) as also indicated by decrease in resistivity. As expected, the general shape of the isothermal annealing curves (figure 1), at different temperatures is very similar.

It was observed that the time at which the films became conducting increases as the annealing temperature decreases. This is expected because the thermally activated process of transformation from the amorphous to the polycrystalline phase will slow down with decrease of annealing temperature. This also explains the broadening of the minima with decreasing annealing temperature. The decrease in sheet resistivity with time (figure 1) may be attributed to the reduction in defect density as shown by the x-ray diffraction results, and in addition chemisorption of oxygen also takes place which further reduces the resistivity of the films (Shanthi *et al* 1980). The sheet resistivity attains a minimum when the defect distribution may be assumed to be in equilibrium (Chopra 1969). The increase in the observed resistivity after the minimum is dominated by the formation of pores and further increase in size of the pores. The SEM photographs (figures 3a, b) corresponding to 37 and 60 min annealing give only pores with their size increasing.

The variation in sheet resistivity with temperature on annealing the SnO_2 film in air is plotted in figure 4. The film showed irreversible decrease in sheet resistivity, perhaps due to the reduction of defect density with increasing temperature. This mechanism governing the resistivity of films is well known (Maissel and Glang 1970). The minimum nearly corresponds to the Debye temperature of SnO_2 [$\sim 500°$ K], so that the largest