Ion Shower Doping of Polysilicon Films on Plastic Substrates for Flexible TFT Arrays

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Performance of thin film transistors (TFTs) used for driving active matrix display devices is greatly affected by contact resistance at source-drain electrodes. The silicon layer underneath the source-drain electrodes need to be heavily doped to ensure good ohmic contact characteristics. In this study, an ion shower doping technique was performed to form source-drain contacts for TFTs on polyethersulphone (PES) substrates. The doped layer was subsequently annealed with an excimer laser to activate the dopant atoms electrically. Sheet resistance values that are lower than 10^3 ohms/sq. are desired for a good ohmic characteristic. Also, the entire doping process must be completed at temperatures below 180°C so as not to damage the plastic substrate.

During the ion shower process, the plastic substrates were heated and the poly-Si films were cracked due to the ion bombardment. At an RF power of 150W which was a standard condition for doping on glass substrates, the temperature of the film surface rose to a temperature as high as 210°C after 30 seconds from the onset of the ion shower. Therefore, the doping time must be limited, and a sufficient ion dose could not be obtained. The resulting sheet resistance value was much higher than 10^3 ohms/sq., whereas a sheet resistance of 400 ohms/sq. was achieved on glass substrates. Additional thermal annealing at 180°C decreased the sheet resistance a little, as shown in Fig. 1, but could not lead to a sufficiently low value to make good contacts.

Fig. 2 shows the sheet resistance values at two different levels of RF power, 100W and 150W, respectively. With the RF power of 100W, the substrate could last much longer inside the doping chamber than with the RF power of 150W. Doping for 2 minutes at 100W resulted in sheet resistance values similar to those doped for 30 seconds at 150W. Fig. 3 shows the variation of sheet resistance values with the doping time. A sheet resistance that was as low as 300 ohms/sq. was accomplished.

Fig. 4 shows the profile of the dopant (phosphorus) concentration measured by the secondary ion mass spectroscopy (SIMS). As the doping time was increased from 3 minutes to 15 minutes, the dopant concentration was increased almost by an order of magnitude. This result agrees well with that shown in Fig. 3 where the sheet resistance was decreased by an order of magnitude with the corresponding increase in the doping time.

In summary, the plastic substrates heated up and caused cracking in the poly-Si during the ion shower process, if the process parameters that were same as those for glass substrates were used. The doping time (or ion dose) could be increased by reducing the RF power for ion generation, and sufficiently low sheet resistance values were obtained.

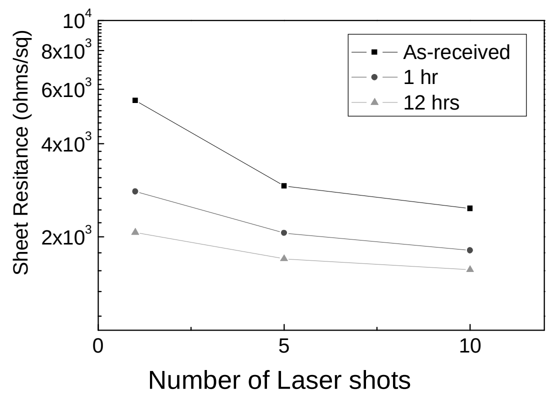

Fig. 1. Change in sheet resistance with additional thermal annealing at 180°C after the laser activation

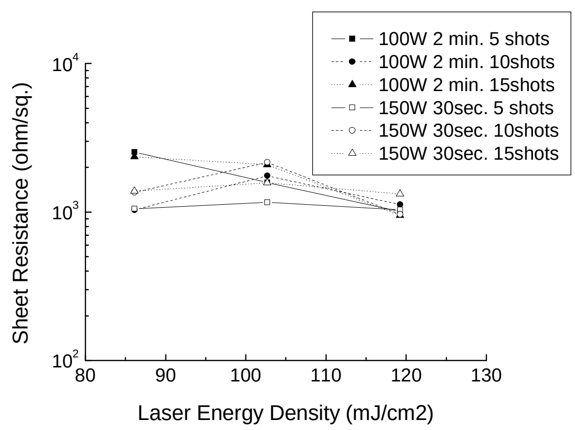

Fig. 2. Change in sheet resistance at two different levels of RF power for generating dopant ions.

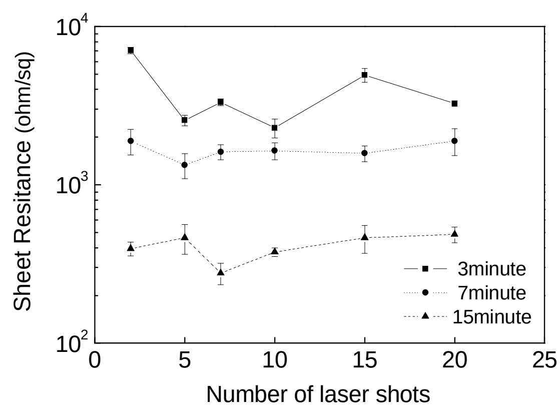

Fig. 3. Change in sheet resistance with increase in the doping time

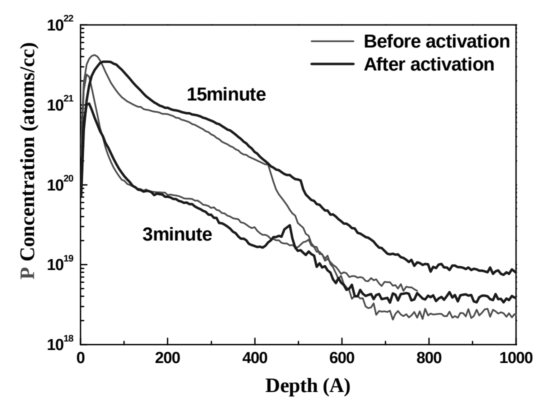

Fig. 4. SIMS profile of the dopant concentration