Field assisted dopant activation of ion shower doped Poly-Si

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Abstract

We report a novel method of activation -annealing, named as induction annealing (IA). IA is realized by applying alternating electric field induced by alternatingmagnetic filed applied to the sample. We observed the enhanced kinetics of dopant activation by using IA.

1. Introduction

Non-mass analyzed ion shower doping technique has been widely used for source/drain doping, for LDD (lightly-doped-drain) formation, and for channel doping in fabrication of low-temperature poly-Si thin-film transistors (LTPS-TFT's) [1,2]. Dopant activation may be done by FA (furnace annealing), RTA (rapid thermal annealing), and ELA (excimer laser annealing), respectively [3]. In this paper we report a novel method of activation-annealing. The proposed method, referred to as induction annealing, involves the induction of alternating magnetic-field to the sample with high frequency during activation-annealing.

2. Experimental

The substrates used were poly-Si produced by excimer laser crystallization (ELC) on 500 Å-thick PECVD (plasma enhanced chemical vapor deposition) a-Si. Phosphorous was implanted by ion shower doping (ISD) with a main ion source of P_2H_x using a source gas of PH_3/H_2.

Induction annealing system used in this study is similar to a conventional solenoid-type induction heating system, as shown in Fig.1. The system consists of 14-turn solenoid-coil to generate alternating magnetic field with a frequency of 14 KHz. The graphite susceptor is located at the center of induction coil. The graphite susceptor is heated first by induction heating. The size of the graphite susceptor is far smaller than the reference depth of induction heating. This set-up allows a large portion of generated magnetic-field not to be consumed by graphite heating. The sample to be annealed is located on the top of the graphite susceptor. The intensity of magnetic field is varied by changing an induction-coil current [4]. The size of graphite was adjusted in order to keep the constant temperature at various coil currents. The surface temperature of heated glass was measured by induction-shielded thermocouple molded to the glass surface.

The implanted samples were annealed at various temperatures and coil-currents. The sheet resistance was measured using a 4-point-probe and the crystallinity was determined by a UV-spectrometer [5].

3. Results and discussion

The ISD samples implanted with 5 kV at a doping time of 1 min were used. These samples were annealed using a tube-furnace at 450°C, 500°C, 525°C, and 550°C, respectively. Induction annealing was performed at 450°C with two different AC-currents applied to a solenoid-coil, 15A and 45A respectively, for the purpose of varying the intensity of alternating magnetic-field.

Fig. 2 shows the sheet resistance as a function of annealing time for the FA-treated samples and for the IA-treated ones, respectively. The sheet resistance decreases with annealing time and temperature for the FA-treated samples. The annealing temperature to obtain the equivalent sheet resistance was reduced to more than 50°C by employing IA. Activation was enhanced by increasing the intensity of magnetic flux. The sheet resistance for the 450°C-30 min IA-treated sample at a coil-current of 15 A approaches almost to the value of the 500°C-30 min FA-treated sample, while that of 45 A is equivalent to the value of the 525°C -30 min FA-treated one. Initial kinetics of dopant-activation was observed to be rather rapid for the case of induction annealing as implied in Fig. 2. Fig. 3 indicates the crystallinity for the ELC poly-Si, the FA-treated samples, and the IA-treated samples, respectively as measured by UV-transmittance.

Damage-recovery is also enhanced by induction annealing similar to dopant-activation. The measured crystallinity, however, is relatively low for all samples involved presumably due to low thermal-budget used in this work, as illustrated in Fig. 3.

Although detailed mechanism of enhanced kinetics of dopant-activation is not understood well, we believe that it may be associated with the electromotive-force (EMF) voltage induced by alternating magnetic-flux, a well-known Faraday law.

4. Conclusions

Activation kinetics was enhanced by employing an induction annealing. Increase of magnetic

flux was observed to accelerate the activation rate. The induced electric-field due to EMF is believed to be associated with the enhanced kinetics.

5. Acknowledgements

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6. References

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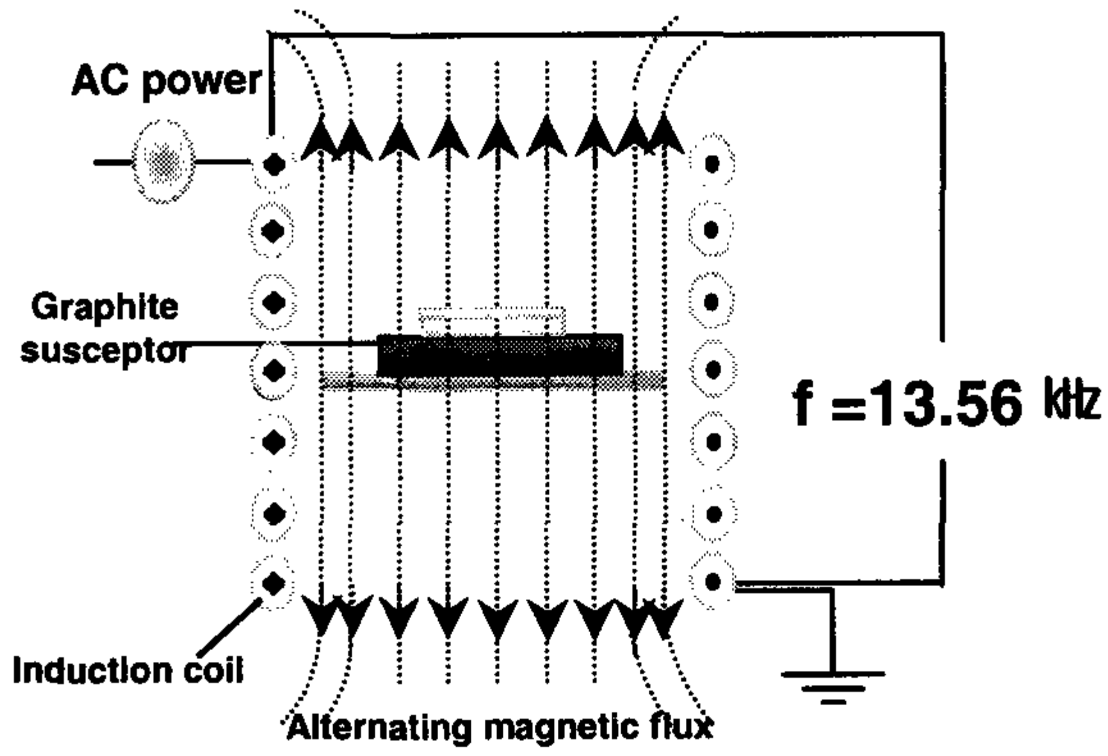

Fig.1 Induction annealing system used in this study

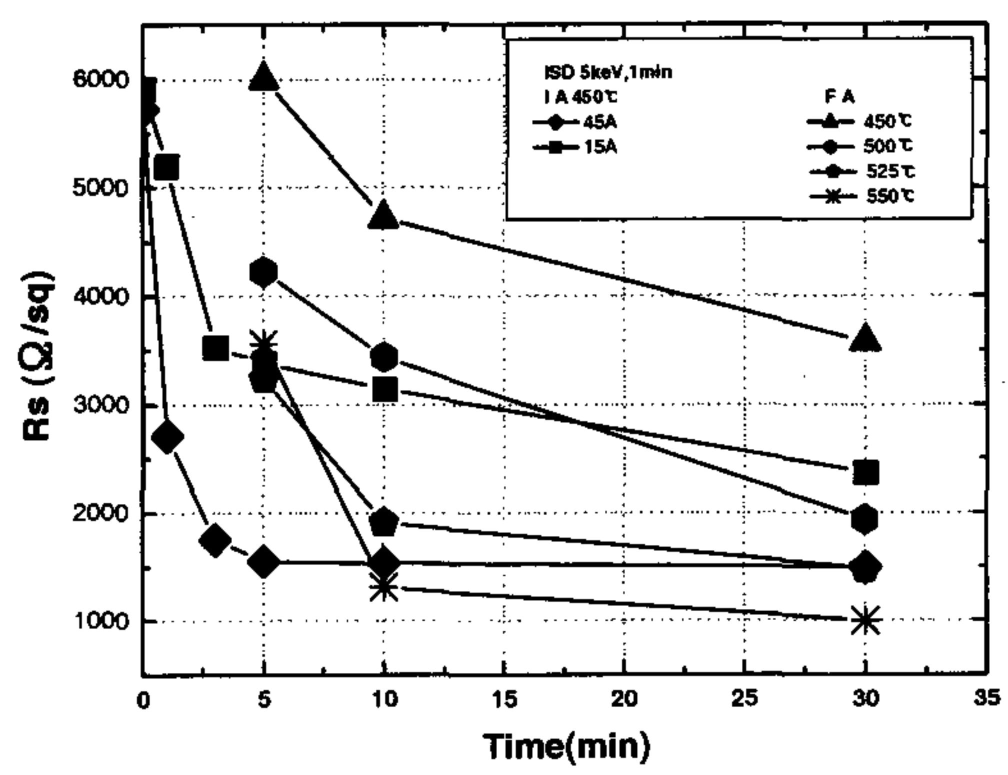

Fig.2 Sheet resistance vs. annealing time.

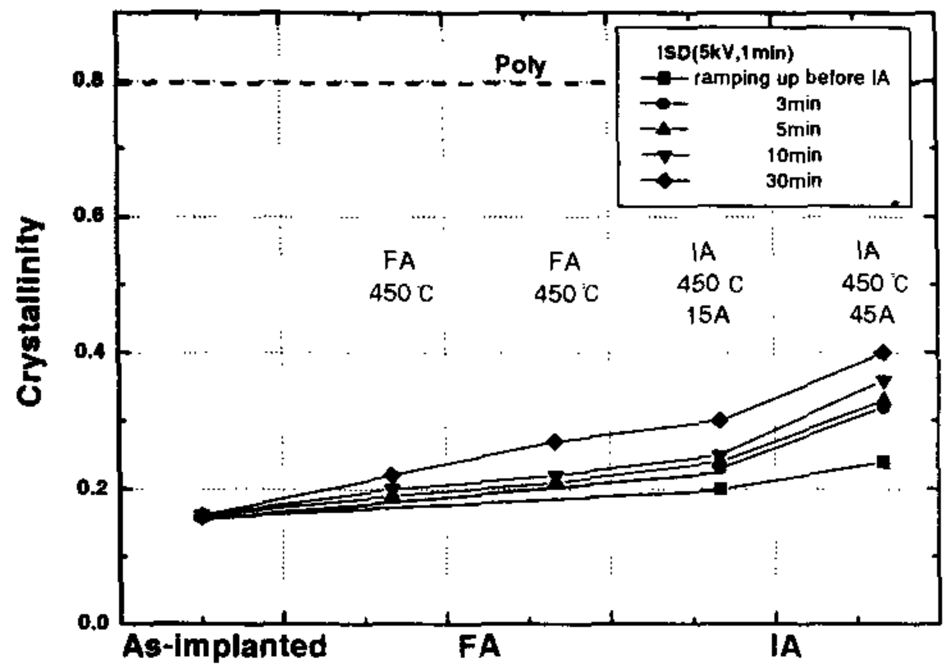

Fig.3 The measured crystallinity for the FA-treated and the IA-treated samples, respectively.