Activation for Boron Doped poly-Si films by Hydrogen doping

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Abstract

When boron ions are doped into the poly-Si films, the hydrogen ions doped with boron ions compensate the defect sites and suppress to produce damage density. These samples can be easily activated by hydrogen doping at high acceleration voltage(V_{acc}).

1. Introduction

The activation for doped poly silicon(poly-Si) films have been studied. In case of ELA(Excimer Laser Annealing) method, it is difficult to recover the damage near the junction beneath gate. The thermal activation method causes glass to be shrunk though more effective to recover the junction defects.

In our study, we introduce new activation method, the hydrogen doping activation(HDA). To improve the activation efficiency, it is necessary to increase of hydrogen contents in poly-Si films. And these hydrogen ions would terminate the dangling bonds and reduce the defect sites[1][2]. The HDA at high V_{acc} can easily activate these samples. It is ascribe to the energy transformation from the kinetic energy to the thermal energy. That is, the lattices of silicon would be vibrated by incident with the highly accelerated hydrogen ions when the hydrogen ions are doped into the poly-Si films at high V_{acc}. Thus, the temperature of substrate is raised with producing little damage density due to small mass. Accordingly, if the damage density is suppressed by increasing the hydrogen ratio during doping process, the doped poly-Si films can be easily activated by using the HDA at high V_{acc}.

2. Experiments

50nm thick a-Si:H layer and 300nm thick buffer-oxide layer were deposited on glass by plasma-enhanced chemical-vapor deposition(PECVD) and atmospheric pressure chemical-vapor deposition (APCVD) system, respectively. And the a-Si layer was crystallized by XeCl excimer laser at 330mJ/cm^2 after dehydrogenation. The bucket type ion doping system(non-mass-separated ion doping system) was used for doping process, and B_2H_6(20% diluted by hydrogen) gas was used for boron doping. We varied doping gas condition with adding hydrogen gas as Table 1, and doped at V_{acc} of 10keV . The activation processes were carried out by furnace at 430°C and HDA at high acceleration voltage.

	B_2H_6	H_2
Case A	50 sccm	0 sccm
Case B	50 sccm	10 sccm
Case C	50 sccm	30 sccm
Case D	50 sccm	50 sccm

Table 1. Hydrogen mixture ratio

3. Results and Discussion

With the same setting dose, 3E15/cm^2, we doped boron ions for case A and case D, and figure 1 shows the secondary ion mass spectrometer (SIMS) profiles for the two cases. The concentration of the doped boron ion is higher about four times in case A than in case D, which is ascribed to the hydrogen contents. Figure 2 shows the Rs characteristics with increase of the activation temperature. When we compare the Rs values of case A and case D with the setting dose of $3E15/cm^2$ and $6E15/cm^2$, respectively, the latter shows lower Rs values than the former, though the former has higher actual concentration in poly-Si film as the SIMS profiles. It is related to the hydrogen passivation for defect sites in grain boundary and suppression of producing damage density during doping process[2]. In case A with dose of $5E15/cm^2$, the Rs values decrease, but the values are until higher than case D with dose of $6E15/cm^2$ due to increase of damage density. In figure 3, at the fixed activation temperature, 430°C, the Rs values of case A are lower than that of case D at dose of $3E15/cm^2$, however, it is almost same and reversed at dose of $4E15/cm^2$and $5E15/cm^2$, respectively. It explains the activation efficiency; in case D, the doped hydrogen ions terminate the dangling bonds and suppress to producing defect sites, which increase the activation efficiency, relatively[7].

Based on these results, we suggest that the doped boron can be activated at the lower activation temperature if the hydrogen ions are added during boron doping process. And we introduce new activation method, the HDA, which was carried out by hydrogen doping at high $V_{acc.}$ When hydrogen ions are highly accelerated and incident with silicon ions and lattices, the atoms and lattices get a kinetic energy. And the kinetic energy is changed to the thermal energy which is accumulated with increase of hydrogen dose and/or doping time. Figure 4 shows the results of the HDA with increase of boron dose and hydrogen contents. For activating the doped boron ions in poly-Si film, the hydrogen ions were doped with dose of $1E16/cm^2$ at the V_{acc} of 80keV, which caused to increase the substrate temperature up to about 250°C. From figure 4, we can find out the effect of hydrogen contents which were doped with boron ions. The lower the activation temperature is, the lower the activation efficiency is. And the effect of damage density becomes conspicuous and dominant in Rs characteristics. Accordingly, we suggest the damage density goes down from case A to case D. Thus, it is easier to activate the films with the high contents of hydrogen ions than with the low contents. Figure5 shows the difference between the thermal activation and the HDA. In case of the thermal activation, the activation efficiency is higher than the HDA. However, if the V_{acc} can be raised, the activation efficiency also can be increased. And there are two significant profit issues; i)the HDA needs shorter activation time(e.g. minutes) than the thermal activation (e.g. hours), and ii)the HDA does not request the additional hydrogenation process after activation unlike the thermal activation[1-4]. The dehydrogenation occur in furnace activation, and the hydrogenation process should be carried out after activation in order to passivate the dangling bond and defect sites within channel region of thin film transistor(TFT)[5-7].

If we can increase the acceleration voltage more and more, the activation efficiency can be improved due to higher temperature. It means that it can be applied to activate the phosphorous doped poly-Si films which have more high density of damage.

4. Conclusions

We introduced the effects of hydrogen contents in the doped poly-Si films and the possibility of the HDA. With combining these two concepts, it is possible to improve the performance of TFTs without additional passivation process and reduce the process. Further development of these concepts, it is necessary to analyze and estimate in detail the relationship between the damage density and hydrogen in poly-Si. And further study is remained for the n-type doped poly-Si films and TFT.

5. References

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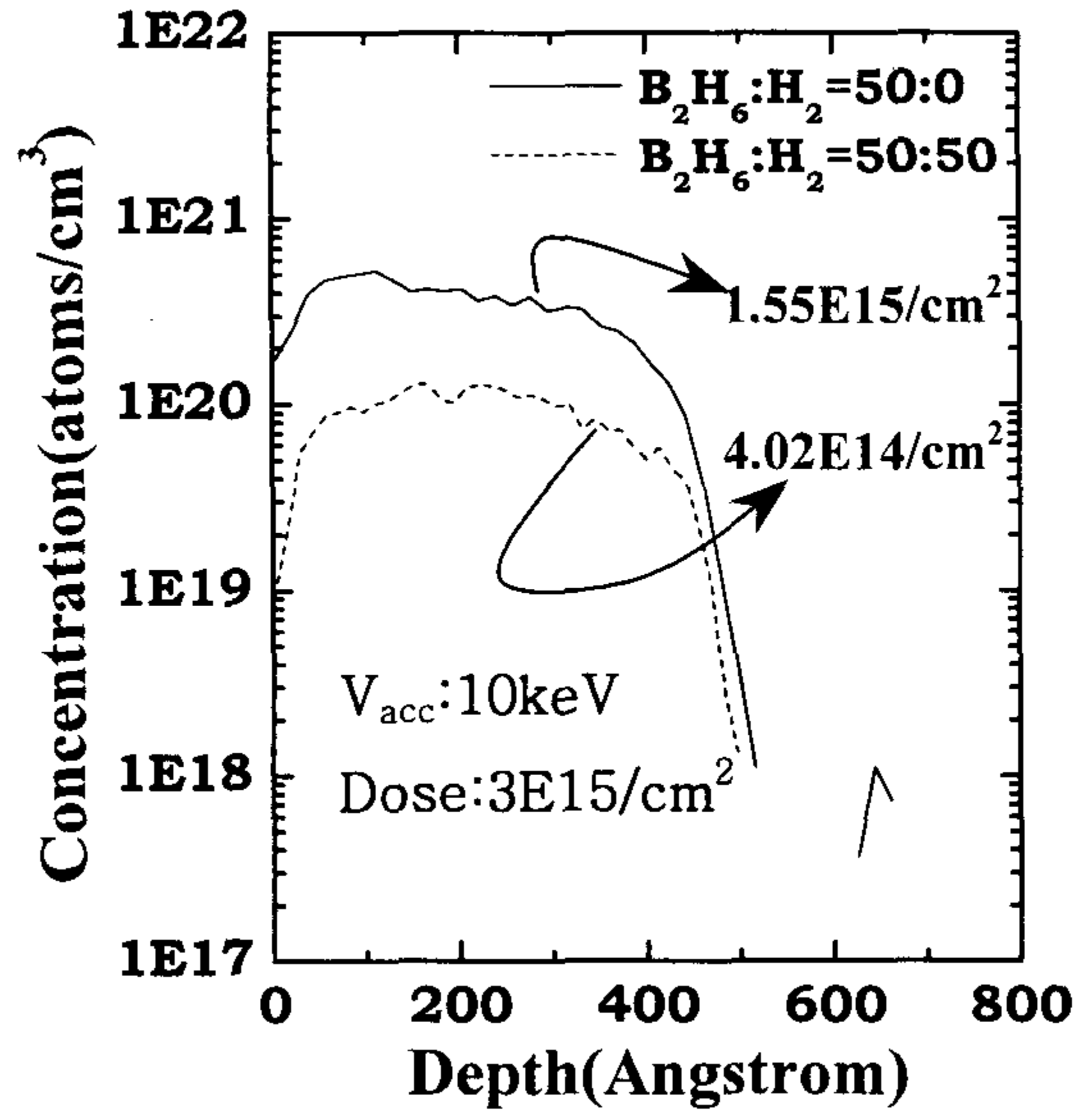

Figure 1. SIMS profiles for doped boron ions (B_2H_6:50sccm:0sccm and 50sccm:50sccm)

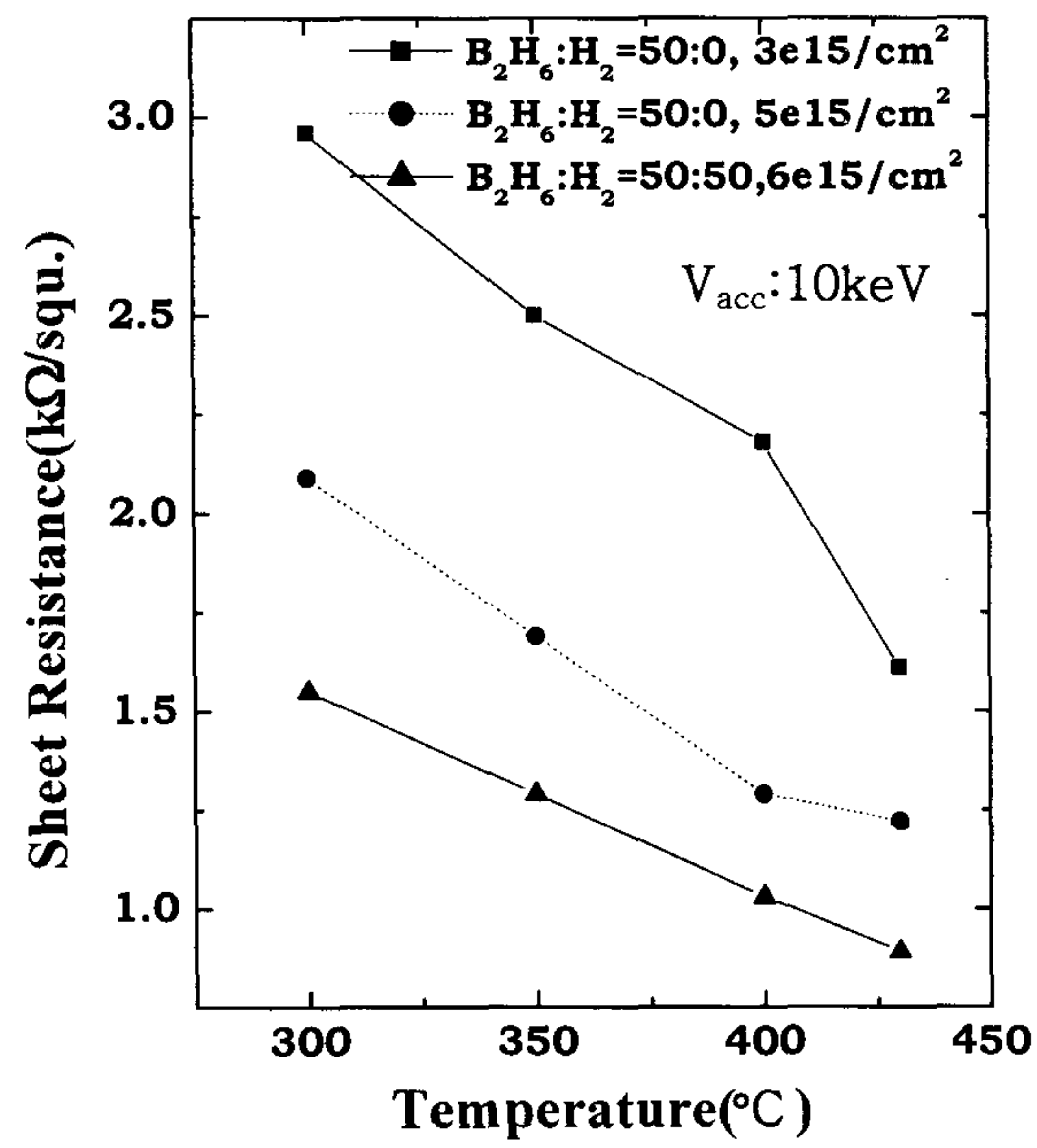

Figure 2. Sheet resistance characteristics with increase of furnace temperature from 300 to 430°C

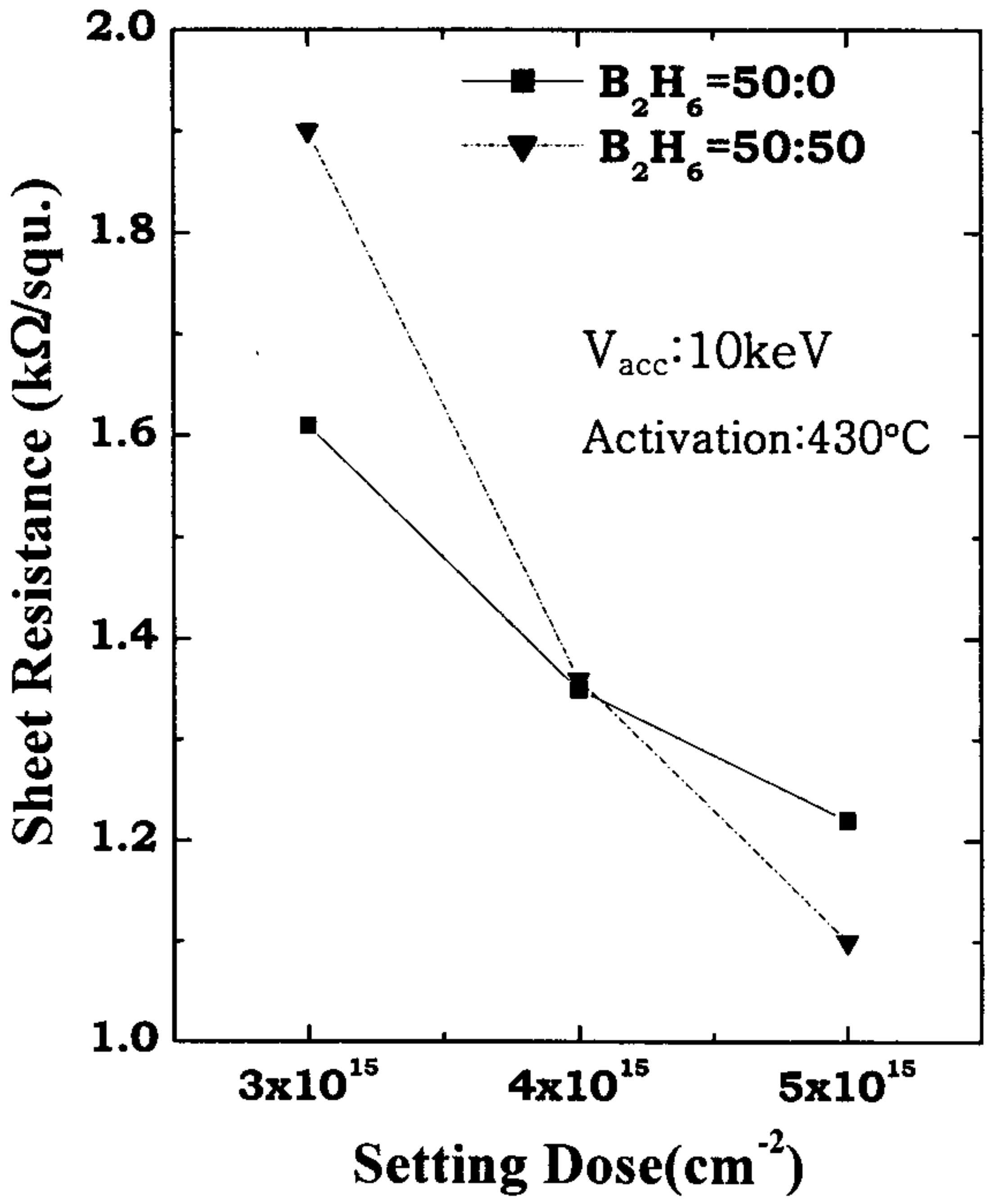

Figure 3. Sheet resistance characteristics with or without hydrogen ions in the doped poly-Si film.

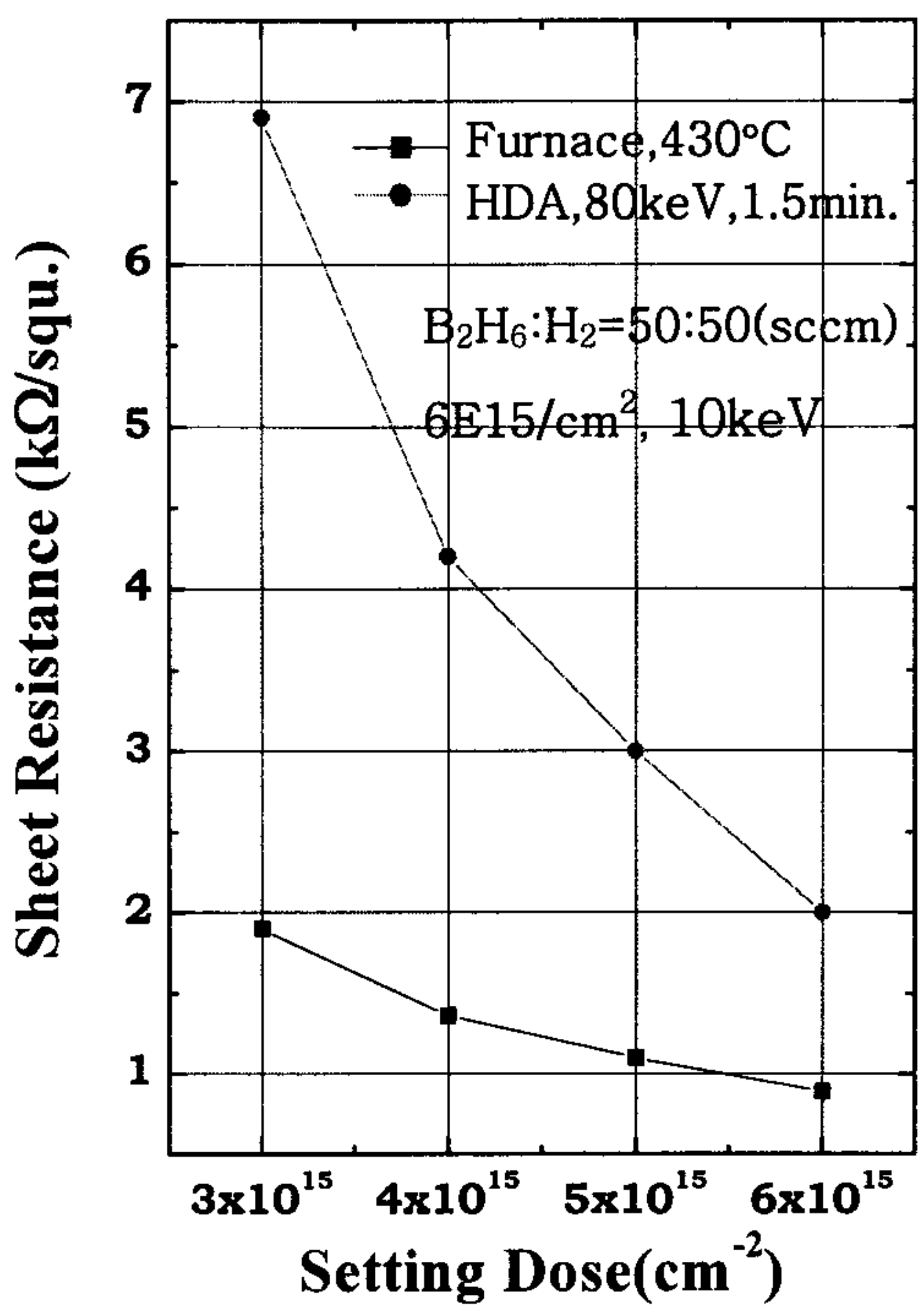

Figure 5. Comparison of activation effici between thermal activation and HDA.

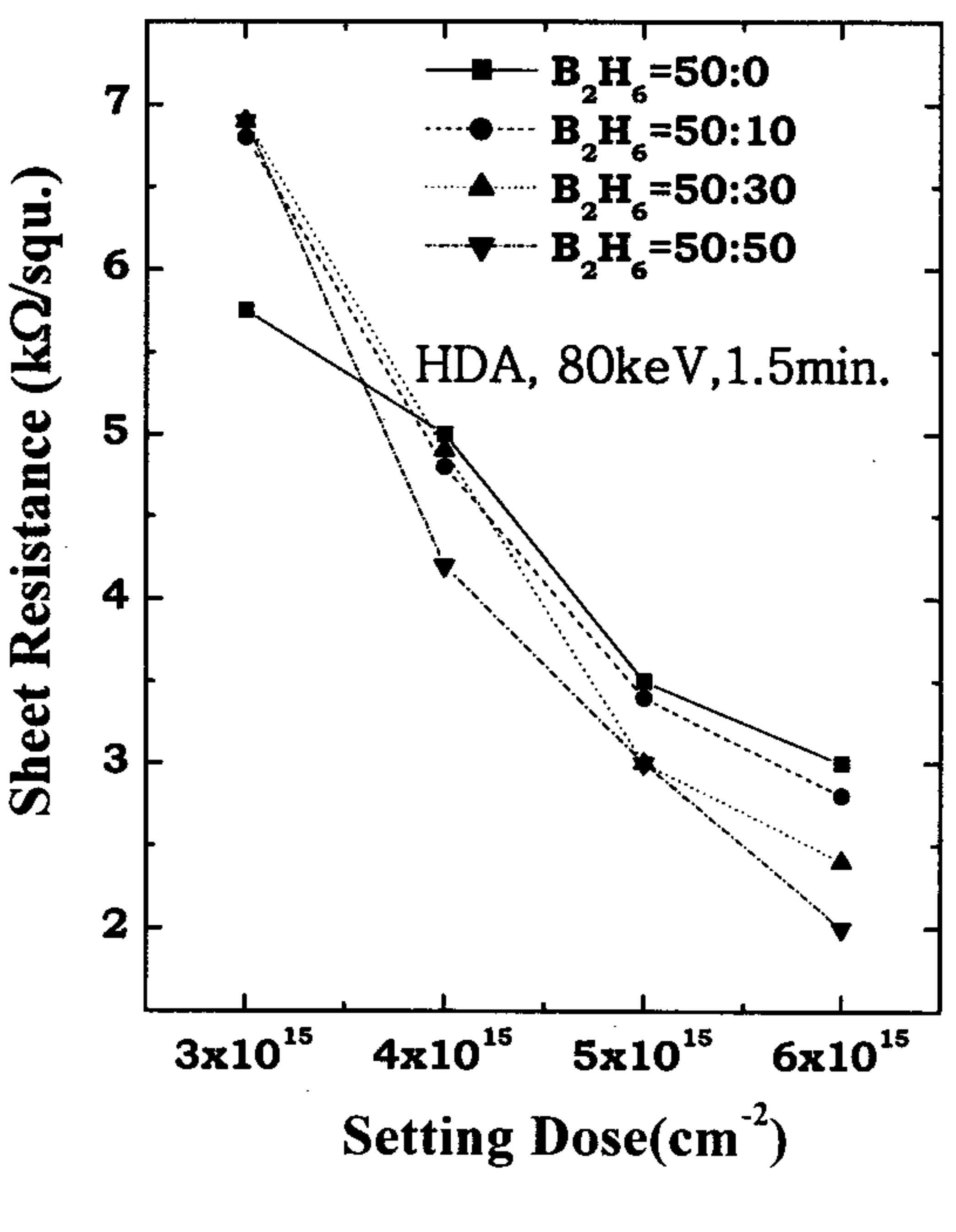

Figure 4. Hydrogen doping activation(HDA). The sheet resistance decreases with increase of hydrogen contents.