Dear editor,

We like to express our appreciation to the reviewers for their comments. We are re-submitting the revised version of the paper number JAP21–AR–DIS2022–05281. We have studied the comments of the reviewer carefully, and have changed the text according to the comments they have listed. The location of revisions is pointed by blue color in "Marked-Manuscript.pdf". Below we refer to each of the reviewers comments.

Response to Reviewer #1

Comment 1. *The English expression is a little awkward in places, but not to the extent that it negatively affects the readability, in my opinion.*

Reply: The text was revised.

Response to Reviewer #2

Comment 1. *In Fig. 4, the numbers identifying the different curves are missing.*

Reply: The curves' numbers were added. We apologize for the inattention.

Comment 2. *Figure 6 is not so relevant, and could be given as supplementary information*

Reply: Figure 6 was transferred to the Supplementary material, the text was revised (page 1, column 1, paragraph 3).

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Response to Reviewer #3

Comment 1. *Page 1, column 2, line 1: The lattice deformation amplitude should have a unit.*

Reply: The "relative deformation" was meant. The term "strain" is used in the revised version.

Comment 2. *Page 1, column 2, paragraph 3: The origin of the iron in the diodes should be explained. How are the diodes contaminated with iron?*

Reply: The technological process of manufacturing solar cells (SCs) based on p-type Cz-Si wafers included the formation of a separating and isotype barriers (n^+-p and p-p^+ junctions) on the front and back surfaces by diffusion of phosphorus ($POCl_3$) and boron (BCl_3) from gas phase, respectively; thermal oxidation; thermal annealing; photolithography; etching the dividing groove; chemical treatments; magnetron sputtering of aluminum contacts to the front and back sides.

It was found that some SC lots are characterized by significantly lower values of parameters compared to typical solar cells for this process. In particular, the photoconversion efficiency was almost halved. The analysis made it possible to establish that the reason for such a strong deterioration in the SC parameters is a sharp drop in the diffusion length of minority charge carriers (electrons) L_n in the SC base. Additional experiments with thermal annealing at temperatures of 200°C and 90°C showed that a sharp drop in the L_n value is due to the presence of an iron impurity with a concentration of up to $4 \cdot 10^{13}$ cm^{-3} in comparison with SC with typical parameters. It was also found that the source of iron impurity is insufficiently pure chemicals that were used for chemical treatments in the technological process, obtained from another supplier. These reagents were the source of contamination in the process of manufacturing experimental SC samples.

To study the effect of ultrasonic loading on the kinetics of the transformation of iron-boron pairs, samples with varying degrees of iron contamination (iron concentration $2 \cdot 10^{12}$-$4 \cdot 10^{13}$ cm^{-3}) were taken.

More detailed information about iron source was added (page 2, column 2, paragraphs 3 and 4).

Comment 3. *Page 1, column 2, paragraph 5: How was the excess carrier density, which is induced by the LED illumination, estimated? This point should be explained.*

Reply: The excess carrier density was estimated by using open-circuit voltage value V_{OC}. According to Sachenko *et. al.*[1]

$$\Delta n = -\frac{n_0}{2} + \sqrt{\frac{n_0^2}{4} + n_i \exp\left(\frac{qV_{OC}}{kT}\right)} \tag{1}$$

where n_0 is the equilibrium electron concentration, n_i is the intrinsic electron concentration.

The short information was added to the revised manuscript (page 1, last paragraph; page 2, first paragraph).

Comment 4. *Figure 2: Short circuit current has the unit μA not μm.*

Reply: The reviewer is quite right. The graph was corrected.

Comment 5. *Page 2, column 2, paragraph 1: The materials doping level is given on page 1 with 10 Ohm cm. This is about 1.4e15cm^{-3} and not 1.4e16cm^{-3} as stated here.*

Reply: The reviewer is quite right. It was a slip. The correction is done.

Comment 6. *Equation 7: The unit of the pre-factor is missing.*

Reply: The Equation was corrected.

Comment 7. *Page 3, column 1, paragraph 3: The obtained iron concentration is compared to results obtained from diffusion length measurements. There should be a reference to these measurements or more details should be given.*

Reply: The diffusion length before (L_{n0}) and after (L_{n1}) pair dissociation was measured using spectral dependencies of short circuit current[2]. Then the iron concentration was determined by using Zoth and Bergholz[3] equation:

$$N_{\mathrm{Fe}}(\mathrm{cm}^{-3}) = 1.06 \cdot 10^{16} \left(\frac{1}{L_{n1}^2} - \frac{1}{L_{n0}^2} \right) (\mu\mathrm{m}^{-2}) \tag{2}$$

The short information was added to the revised manuscript.

Comment 8. *Figure 4: The numbers of the curves given in the caption are not included in the graphs. This must be improved otherwise the figures cannot be understood. Each graph should also be marked by a letter. What is "G" at the x-axis of the inset? This should be explained.*

Reply: The graphs were revised. The curves' numbers were added. Each graph was marked by a letter. "G" was changed by "Will" (radiation intensity of halogen lamp). We apologize for the inattention.

Comment 9. *Figure 5: This plot is confusing and must be revised. What is the main statement of this figure? What are the differences between the samples and why do the*

results change from sample to sample? The axes should have the same scaling. What are the light blue bars in (a)?

Reply: Figure 5 was changed by Table . The main assignment of this data is illustration of i) USL actually does not influence the τ_{dis} magnitude;
ii) some pairs do not dissociate under illumination in the USL case when light–induced pair dissociation is close to saturation. The decrease in illumination intensity reduces last effect at the given illumination times.

The main differences between the samples are the iron concentrations. However, as it can be seen from the data, the effect of ultrasound does not qualitatively change with the iron concentration alteration (from sample to sample). The value of acousto-induced change in $N_{\text{Fe,fit}}$ value depends on ultrasound intensity (see data for sample SC350-1, $W_{\text{ill}} = 0.16$ W/cm^2) and frequency.

The dissociation rate of FeB pairs depends on iron concentration, light intensity, and temperature[4–7]. These is a reason of τ_{dis} value change from panel to panel in Fig. 5 in the unrevised manuscript (from row to row in Table I in the revised manuscript)

The light blue bars in Fig. 5(a) (the unrevised manuscript) corresponded to another ultrasound intensity (0.6 W/cm^2).

Comment 10. *Main Problem The impact of ultrasound on the iron-boron-pair reaction was first reported by Ostapenko and Bell in 1995 [1]. They found that the iron boron pairs dissociate due to an ultrasound treatment. This is in contradiction to the findings, which are reported herein. In the contribution under review it is found that the association of the FeB pairs is enhanced by the ultrasound treatment. This contradiction must absolutely be discussed by the authors otherwise the manuscript cannot be published. [1] S. S. Ostapenko and R. E. Bell, "Ultrasound stimulated dissociation of Fe-B pairs in silicon," J. Appl. Phys., vol. 77, no. 10, p. 5458, 1995.*

Reply: The

REFERENCES

[1]A. V. Sachenko, Y. V. Kryuchenko, V. P. Kostylyov, A. V. Bobyl, E. I. Terukov, S. N. Abolmasov, A. S. Abramov, D. A. Andronikov, M. Z. Shvarts, I. O. Sokolovskyi, and

M. Evstigneev, J. Appl. Phys. **119**, 225702 (2016).

[2]E. D. Stokes and T. L. Chu, Appl. Phys. Lett. **30**, 425 (1977).

[3]G. Zoth and W. Bergholz, J. Appl. Phys. **67**, 6764 (1990).

[4]J. Schmidt, K. Bothe, V. V. Voronkov, and R. Falster, physica status solidi (b) **257**, 1900167 (2020).

[5]L. J. Geerligs and D. Macdonald, Appl. Phys. Lett. **85**, 5227 (2004).

[6]N. Khelifati, H. S. Laine, V. Vhnissi, H. Savin, F. Z. Bouamama, and D. Bouhafs, Phys Status Solidi A **216**, 1900253 (2019).

[7]J. Lagowski, P. Edelman, A. M. Kontkiewicz, O. Milic, W. Henley, M. Dexter, L. Jastrzebski, and A. M. Hoff, Applied Physics Letters **63**, 3043 (1993).