

Influence of illumination spectrum on dissociation kinetic of iron-boron pairs in silicon

Oleg Olikh* Oleksandr Datsenko Serhiy Kondratenko

Prof. O. Olikh, Dr. O. Datsenko, Prof. S. Kondratenko

Taras Shevchenko National University of Kyiv, 64/13, Volodymyrska Street, 01601, Kyiv, Ukraine

Email Address: olegolikh@knu.ua

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Please insert your abstract here

1 Introduction

Defects significantly impact semiconductor properties. Although minimizing device dimensions to nanometers shifts some focus from extensive to point defects, physical properties still rely heavily on the presence and distribution of these irregularities. Hence, many strategies for enhancing semiconductor structures, including radiation and temperature treatments or certain fabrication conditions, strive to decrease the defect concentration or neutralize its effects [1, 2, 3]. For instance, in the case of photovoltaic devices, we must understand and optimize the carrier properties tied to defects and impurities [1]. Such controlled alteration methods of the defective subsystem have been generalized under the term “defect engineering” and are extremely important from a practical standpoint.

Successful defect engineering hinges on an in-depth understanding of defect properties. Key factors are defect formation energy, transition energy levels, self-compensating effects, nonradiative recombination caused by defects, and the mechanism of reconstruction and diffusion [1]. Considering the extraordinary diversity of possible intrinsic and impurity defects, complete information on all of them is lacking even for silicon, which is the most studied semiconductor. Nevertheless, it must be noted that considerable data have been amassed on silicon, and have a solid understanding of some defects [4].

For instance, such defects are iron impurity, a common, detrimental, and often unavoidable contaminant in photovoltaic silicon [3, 5], and iron-boron pair. Specifically, iron atoms are known to be at the interstitial sites, and Fe_i^+ are highly efficient recombination centers [6]. In p-type Si at room temperature, iron atoms are almost predominantly bound in complexes with dopants (B, Ga, Al, In). This defect demonstrates bistable behavior: the stable state is defined by the configuration in which the Fe occupies the first nearest tetrahedral interstitial site closest to the substituent atom, whereas, in the metastable configuration, Fe is at the second T_d interstitial site [7]. The energy levels associated with iron and its complexes, as well as the respective carriers capture cross-sections, are well-established [4, 8]. Among the acceptor-iron pairs, the complex FeB is the most thoroughly investigated, primarily due to the widespread use of Si:B in the fabrication of various devices, such as solar cells. However, it is worth mentioning that gallium is gaining increasing attention as an acceptor dopant whose incorporation, for instance, can help mitigate the light and elevated temperature-induced degradation [9].

It is known that FeB pairs can be dissociated by illumination, minority carrier injection and thermal treatment at 200 ° [10].

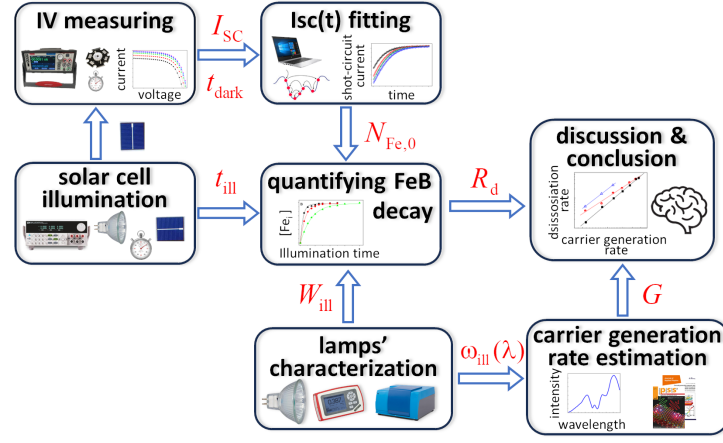


Figure 1: Investigation framework

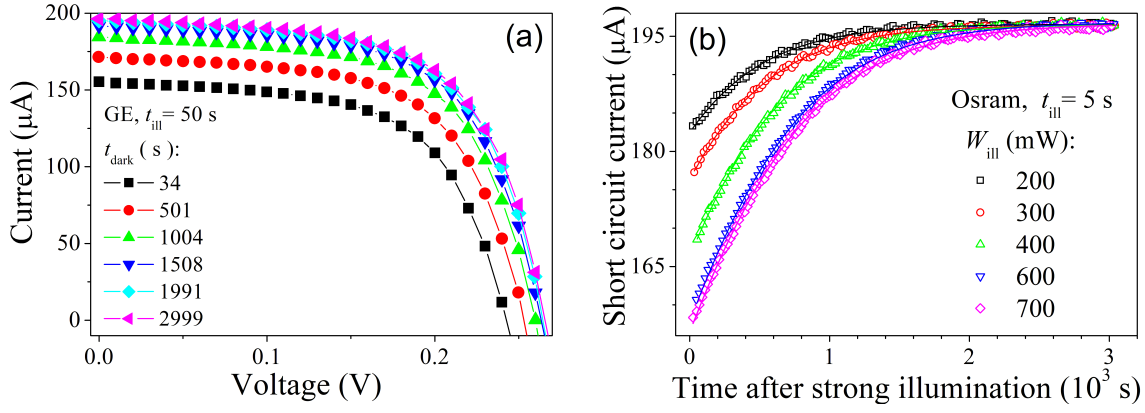


Figure 2: Typical current-voltage characteristics measured under low-intensive (LED) illumination across different periods following exposure to strong light (halogen lamp) (panel a) and short circuit current plotted as a function of the time after high-intensive illumination (panel b). The marks are the experimental results and the lines on panel b are the curves fitted according to [11, 12]. Light sources: GE (a), Osram (b). t_{ill} , s: 50 (a), 5(b). $W_{ill} = 50$ mW (b). $T = 340$ K.

Table 1: The value of maximum concentrations of iron atoms after illumination and characteristic dissociation time obtained by approximating experimental dependencies by Eq. (??). Coefficient of determination is listed as well.

W_{ill} [mW]	Light source	τ_{dis} [s]	$N_{Fe,fit}$ [10^{12} cm $^{-2}$]	R^2
750	Orion	2.2 ± 0.2	8.6 ± 0.1	0.993
700	Orion	2.4 ± 0.2	8.5 ± 0.1	0.995
	Osram	2.4 ± 0.2	8.6 ± 0.1	0.992
600	Orion	3.7 ± 0.2	8.65 ± 0.06	0.998
	Osram	3.0 ± 0.2	8.69 ± 0.08	0.995
500	Orion	5.5 ± 0.2	8.65 ± 0.04	0.999
	Osram	4.5 ± 0.1	8.7 ± 0.1	0.998
400	Orion	8.8 ± 0.3	8.74 ± 0.06	0.998
	Osram	6.1 ± 0.2	8.63 ± 0.08	0.997
	GE	3.6 ± 0.3	8.7 ± 0.1	0.996
300	Orion	15.7 ± 0.6	8.6 ± 0.1	0.998
	Osram	12.4 ± 0.1	8.69 ± 0.02	0.999
	GE	6.5 ± 0.2	8.69 ± 0.05	0.998
200	Orion	42 ± 3	8.6 ± 0.3	0.998
	Osram	20.0 ± 0.7	8.53 ± 0.09	0.999
	GE	15.1 ± 0.5	8.7 ± 0.1	0.999

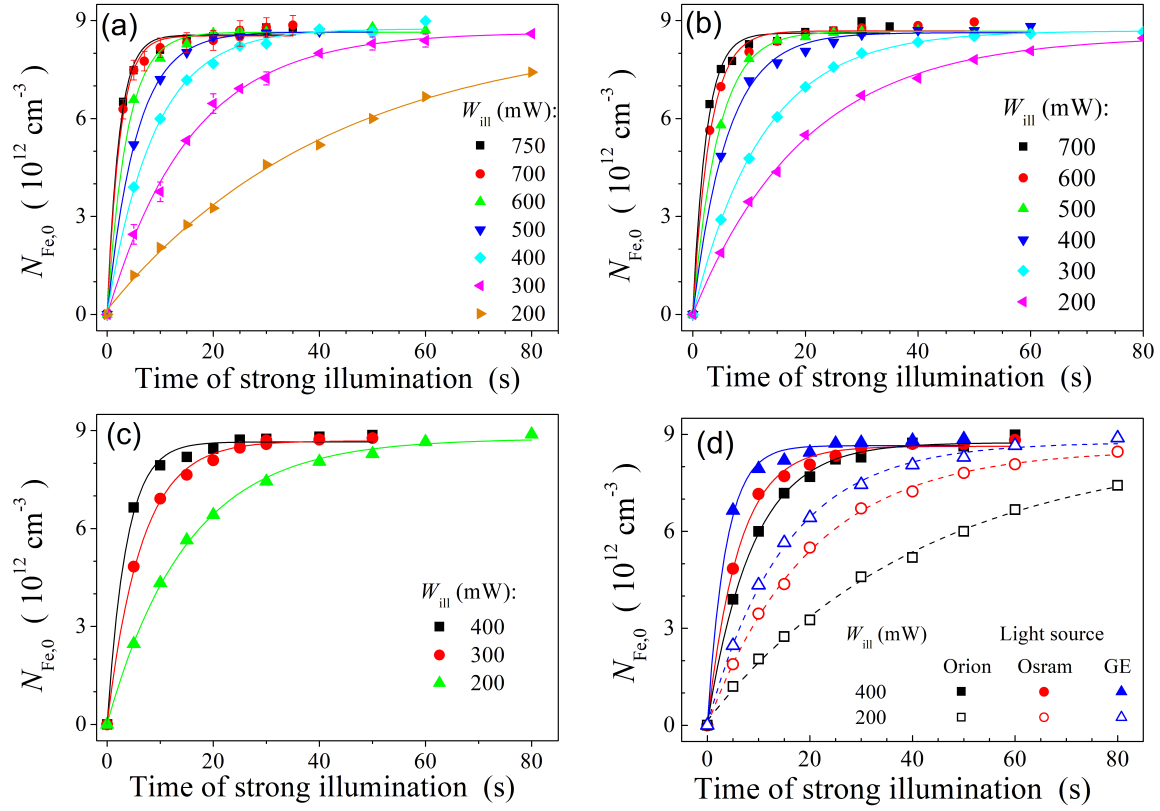


Figure 3: The relationships between the concentration of FeB pairs following intense illuminations of varying intensities and the illumination duration. Light source: Orion (a), Osram (b), GE (c). Panel d highlights variations in the dissociation of pairs induced by different light sources. The marks are the experimental results, the lines are the fitted curves using Eq. (??). $T = 340 \text{ K}$.

Table 2: Table 1 caption

Description 1	Description 2	Description 3
Row 1, Col 1	Row 1, Col 2	Row 1, Col 3
Row 2, Col 1	Row 2, Col 2	Row 2, Col 3

2 Results and Discussion

2.1 First Subsection

3 Conclusion

4 Experimental Section

First part of experimental section:

Second part of experimental section:

Supporting Information

Supporting Information is available from the Wiley Online Library or from the author.

Acknowledgements

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Conflict of Interest The authors declare no conflict of interest.

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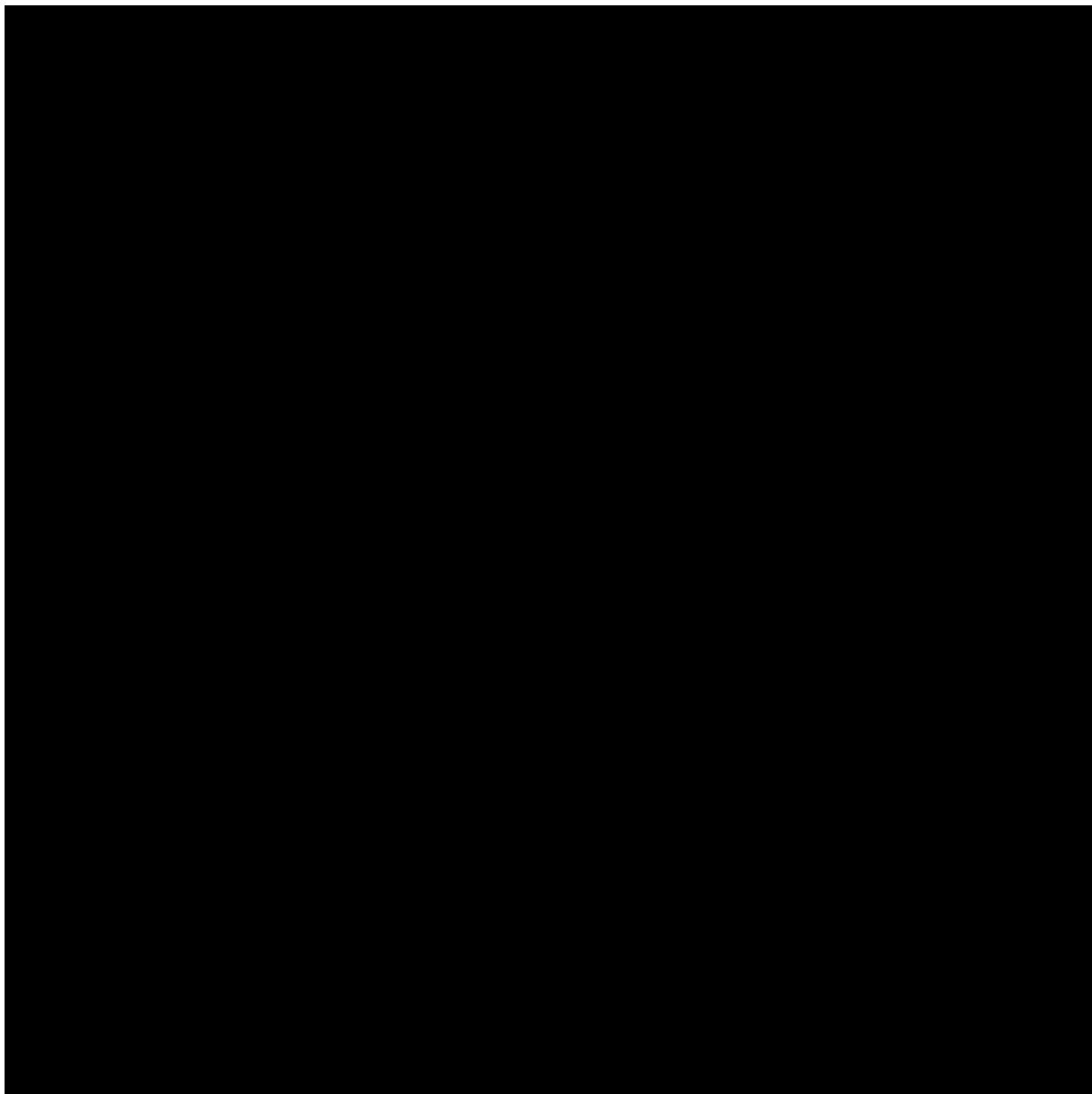


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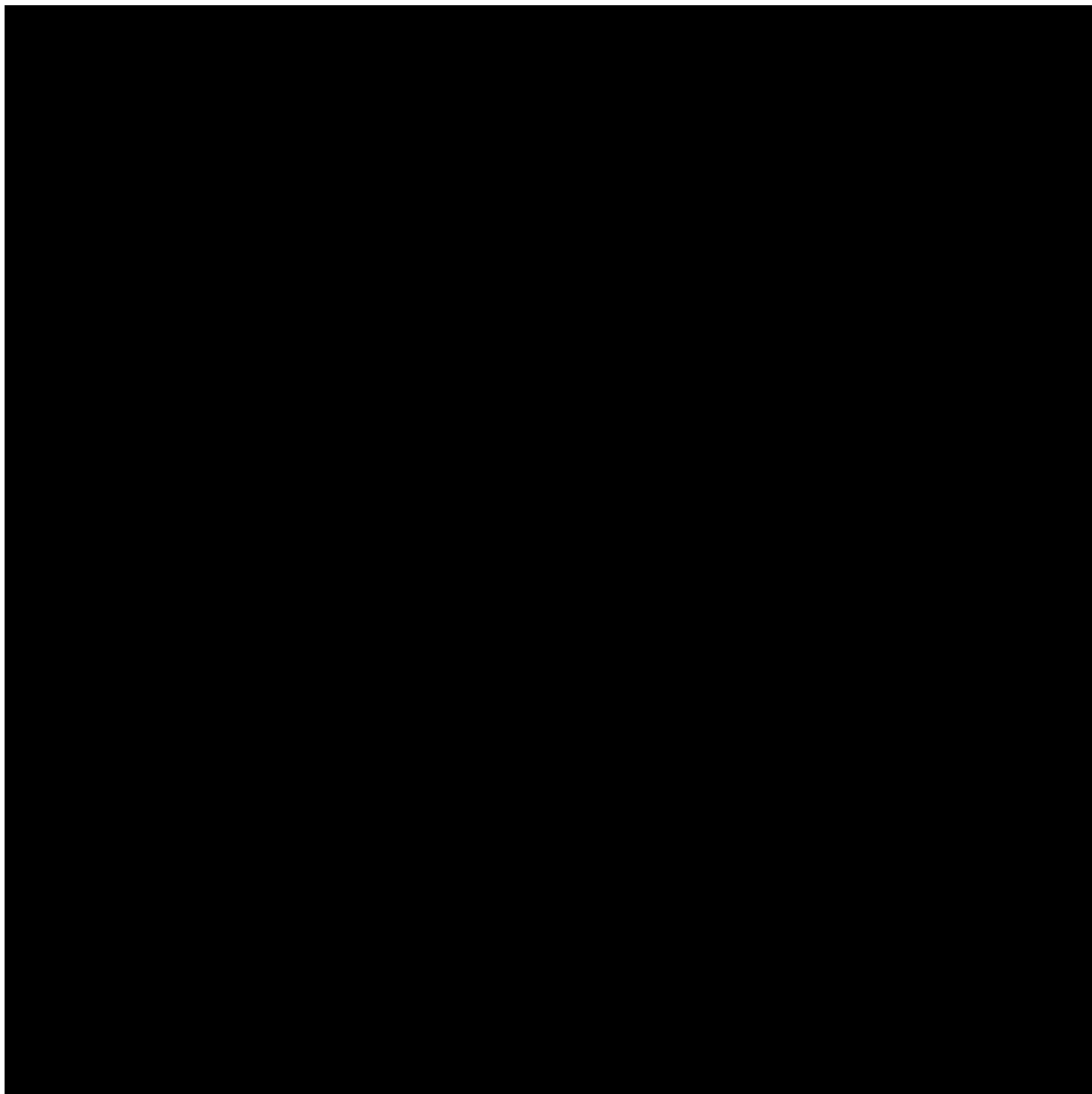


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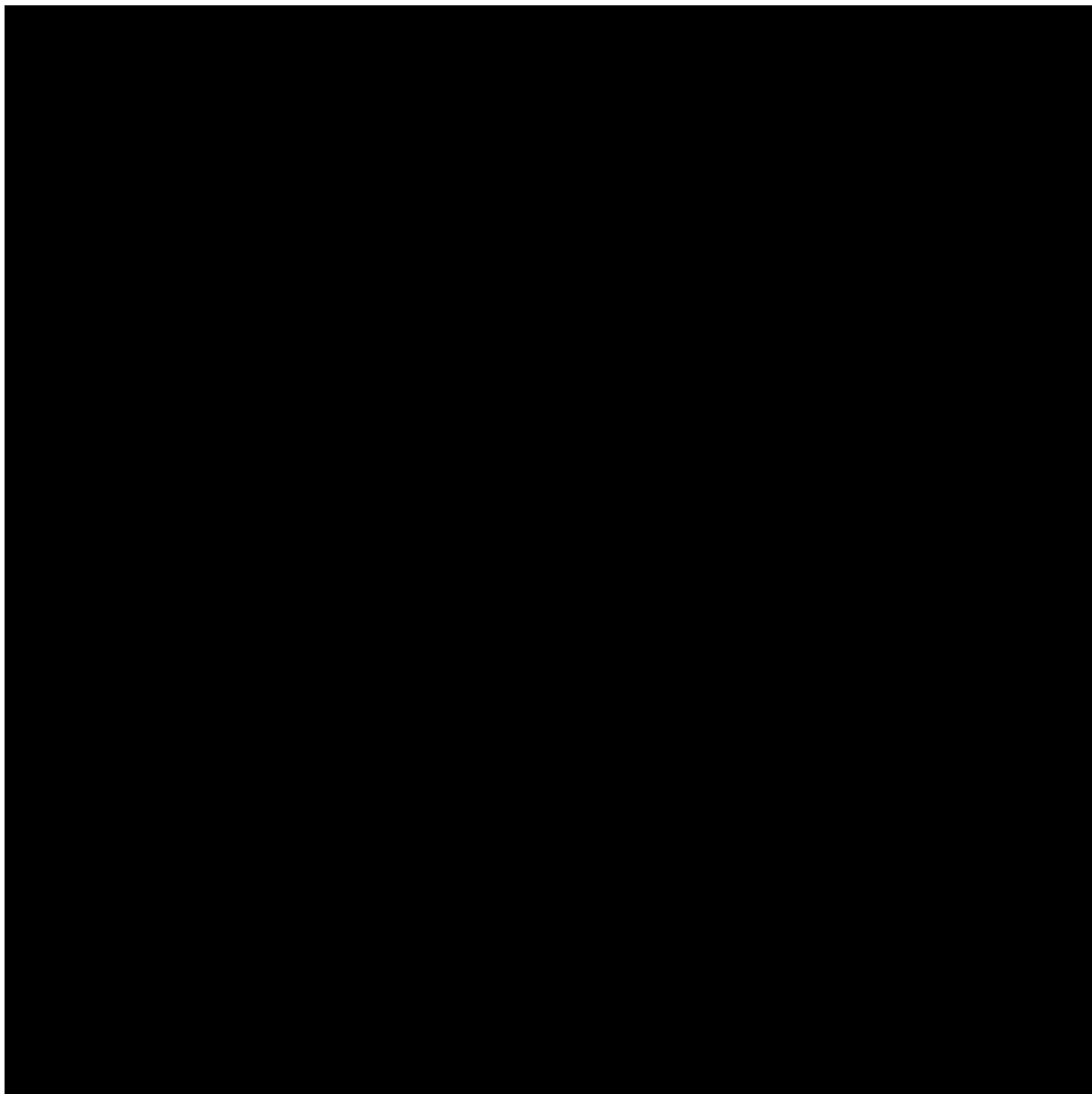
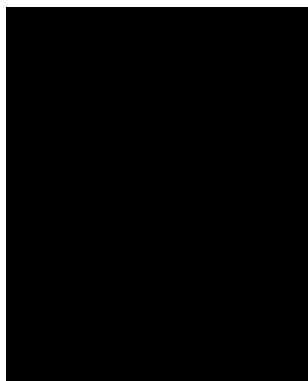


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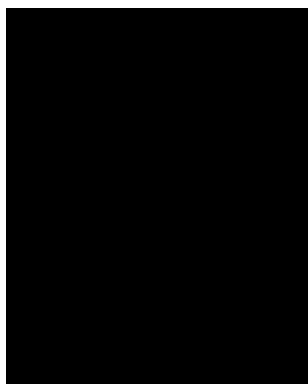
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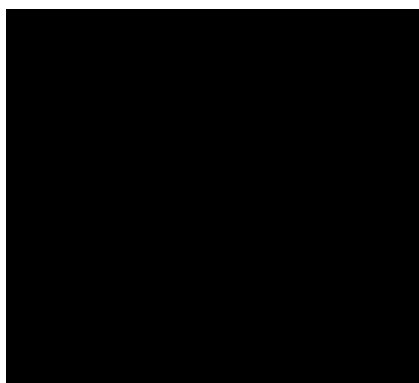
Biography



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