

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MONOLITHIC POWER SYSTEMS, INC.,

Petitioner,

v.

GREENTHREAD, LLC,

Patent Owner.

Case No: IPR2024-00468, 69, 70

U.S. Patent No. 8,421,195; 9,190,502; 11,121,222

**DECLARATION OF DR. STEPHEN CAMPBELL IN SUPPORT OF
PETITIONER'S REPLY TO PATENT OWNER'S RESPONSE**

1. I, Stephen Campbell, submit this declaration in support of Petitioner's Reply to Greenthread's Patent Owner Response in PTAB Case Nos. 2024-00468, 69, 70, for Patent Nos. 8,421,195; 9,190,502; 11,121,222.

2. I have previously submitted a declaration as Exhibit 1003, which contains background materials. I will not repeat them here. I submit this short declaration to address a few items.

3. As I have noted in my original declaration, a carrier will drift according to the electric field applied to it. Portions of ¶ 32 of Exhibit 1003 are excerpted below:

When a high-energy collision takes place in a semiconductor, it creates a very large number of negatively charged electrons and positively charged holes. Of particular interest are the minority carriers such as electrons in a p-type region. If enough of these electrons are collected by the circuitry on the surface of the semiconductor, they can introduce faults in the circuit. As will be discussed, these charged species move in response to an electric field, and so an electric field that is properly constructed will push the minority carriers away from the surface, making their collection much less probable.

4. To further expand, a downward doping gradient creates an electric field that will aid the movement of all carriers downward (but also reduce the upward movement of minority carriers whose initial creation state has an upward velocity). When an x-ray or charged particle strikes the silicon it creates many minority carriers with a wide range of velocities. Some of the minority carriers move upward due to the initial velocity, and some also move downward initially. According to the most

basic equation of Physics ($F = ma$), the electrostatic force created by the dopant concentration creates a downward acceleration that affects all carriers. An electron needs a force applied upon it to cause it to drift and the stronger the field the stronger the force. This will reduce the upward velocity of all of the minority carriers in the region of the doping profile for those carriers whose initial velocities are upwards. Minority carriers with an initial large upward vertical velocity are slowed by the field, but minority carriers with moderate or low initial upward velocities are unable to cross the electric field region, and begin moving downward toward the substrate where they eventually recombine. The wide distribution of the initial minority carrier velocities means that both a reduction of the upward movement of minority carriers and the formation of a downward movement of minority carriers is created.

5. I note that the “totally blocking all” minority carriers from crossing regions (e.g., from a substrate portion to a well) is an impractical scenario because some electrons created via an alpha-ray at a junction (e.g., substrate/well) may jump upwards and cross that boundary due to their initial velocities after electron creation, or they may otherwise have high velocities initially upon their creation.

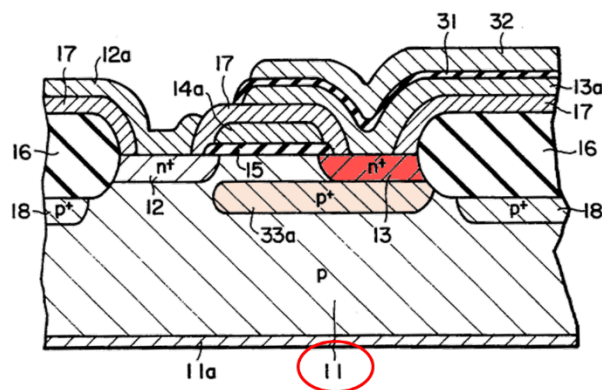
6. I further note that, if a graded dopant concentration exists, it will cause carrier drift. Dr. Glew states that Nishizawa and Kawagoe teach preventing upward movement of electrons, as opposed to aiding their movement downwards. This is wrong and defies logic.

7. Once an electron is generated via alpha rays in Nishizawa and Kawagoe, it will be affected by the drift field created by their respective graded dopant concentrations. This is a downward force to cause electrons to drift downwards. To state that the references teach only preventing upward movement and they do not drift electrons downwards (as Dr. Glew does) effectively means that electrons must be locked in place. This is highly impractical because to accomplish this, a specific upward force would need to be introduced into the device to precisely counteract the one introduced by the dopant gradient. This is not described in Nishizawa and Kawagoe and, moreover, defies logic as it would be impossible (and pointless) to design a force to exactly counteract that introduced by the graded dopant concentration. When a graded concentration prevents upward movement, a POSITA would understand that it causes a downward drift of electrons.

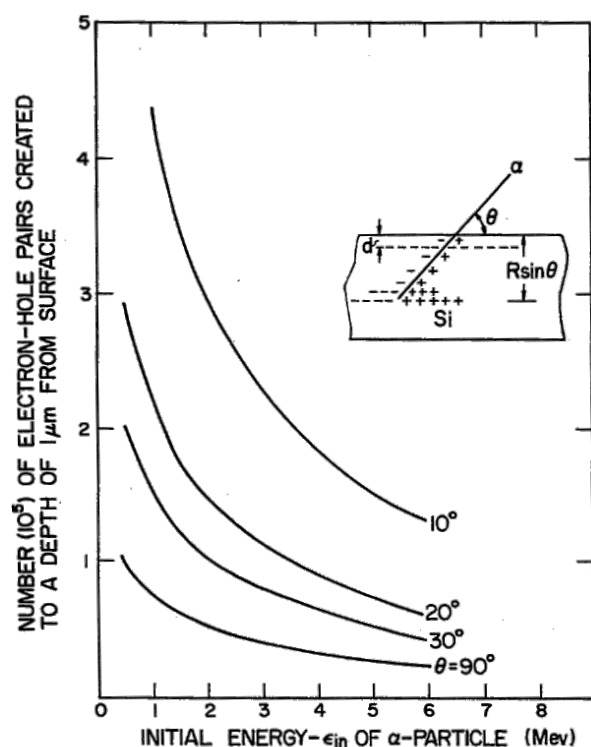
8. However, as I described in my original declaration, both Nishizawa and Kawagoe explicitly describe a downward force introduced by the dopant gradient to apply a force to aid the movement of electrons downwards (and not just prevent upward movement).

9. Nishizawa describes downward drift of electrons in its problem / solution statements for specific issues. Nishizawa teaches that a p⁺ type buried region 33a (tan) that has a uniform concentration will prevent electrons in the p-type substrate 11 (red circle) from entering the p⁺ type buried region 33a. (Nishizawa at

18:4-22.) This has a problem though as stated by Nishizawa: a uniform concentration p^+ type buried region 33a does not address those electrons created by alpha-rays in the p^+ type buried region 33a, and prevent them from reaching the n^+ type region 13. (*Id.* at 18:35-43.) To aid the electron's movement downwards to the substrate 11, Nishizawa teaches "it is only necessary to form an impurity concentration gradient in the p^+ type buried region 33a in the direction toward the p type substrate 11." (*Id.* at 18:46-50.) In other words, Nishizawa is stating that the only thing needed in the p^+ type buried region 33a to cause electrons to drift down is to introduce a new force via a graded dopant concentration. I further note that FIG. 35 is applicable to FIG. 16 which I also discussed in my earlier declaration. (Nishizawa at 20:23-27).

FIG. 35

10. Moreover, I note that it was suggested that Nishizawa does not create electrons at its surface. This is untrue, as there will simply be fewer electrons at the surface than deeper in the device. This is plainly shown in FIG. 36 and 19:67-20:5.

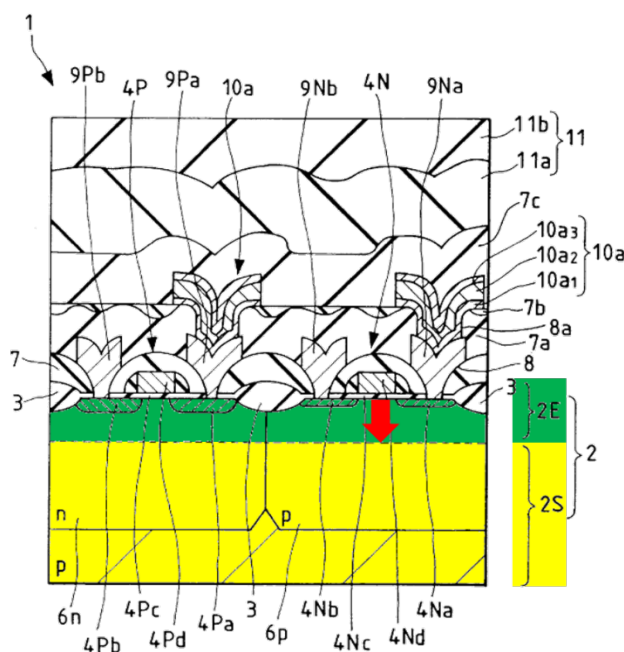
FIG. 36

11. Nishizawa is explained in more detail in my original declaration.

12. Kawagoe also explicitly describes downward drift of electrons via a graded dopant concentration in several locations. Kawagoe teaches: “electrons produced by the α -ray are attracted to the substrate body 2S.” (Kawagoe at 16:7-9.) This means that Kawagoe recognizes that there will be α -rays hitting outside of the substrate body 2S (yellow), e.g., at epitaxial layer 2E (green) and there will be electrons that are affected by the force of the graded dopant profile and will drift (red arrow). Kawagoe further recognizes that electrons will be created in the layer 2e because its purpose is to reduce the influence of α -rays by including a graded dopant concentration “from the surface of the epitaxial layer 2E, so that the influence to be

caused by the carriers (or electrons) due to the α -ray is lowered.” (Kawagoe at 16:2-7.) Kawagoe further contains literal teachings that “electrons produced by the α -ray are attracted to the substrate body 2S.” (*Id.* at 16:7-9.)

FIG. 16



13. Kawagoe is discussed in detail in my original declaration.

14. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are belied to be true; that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on February 14, 2025 in Arden Hills, Minnesota.

Stephen Campbell

Stephen Campbell