

(12) **United States Patent**
Russo et al.

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(54) **PROXIMITY SENSOR HAVING ARRAY OF GEIGER MODE AVALANCHE PHOTODIODES FOR ESTIMATING DISTANCE OF AN OBJECT TO THE ARRAY BASED ON AT LEAST ONE OF A DARK CURRENT AND A RATE OF CURRENT SPIKES GENERATED IN DARK CONDITIONS**

USPC 356/4.01, 5.01, 4.07, 3; 250/221, 559.4, 250/559.29, 206.1, 206, 214 R, 214.1, 250/214 A, 214 VT, 332, 208.1, 393
See application file for complete search history.

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(56) **References Cited**

U.S. PATENT DOCUMENTS

5,592,523 A * 1/1997 Tuy A61B 6/032 250/370.09
7,301,608 B1 * 11/2007 Mendenhall G01S 17/107 356/4.01

(Continued)

OTHER PUBLICATIONS

Akil et al., "A multimechanism model for photon generation by silicon junctions in avalanche breakdown", IEEE Transactions on Electron Devices, vol. 46, No. 5, May 1999, pp. 1-7.

(Continued)

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(58) **Field of Classification Search**
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(57) **ABSTRACT**

A proximity sensor may include an array of Geiger mode avalanche photodiodes, each including an anode contact and a cathode contact. A common cathode contact may be coupled to the cathode contacts of the array to define a first connection lead at a back side of the array. A common anode collecting grid contact may be coupled to the anode contacts of the array to define a second connection lead of the array. Circuitry may be coupled with the first and second connection leads and configured to sense at least one of a dark current and a rate of current spikes generated in dark conditions, and generate an output signal representing an estimated distance of an object from the array upon the sensing.

15 Claims, 4 Drawing Sheets

