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(54) **THIN MULTI-APERTURE IMAGING SYSTEM WITH AUTO-FOCUS AND METHODS FOR USING SAME**

(71) Applicant: **Corephotonics Ltd.**, Tel-Aviv (IL)

(72) Inventors: **Gal Shabtay**, Tel Aviv (IL); **Noy Cohen**, Tel Aviv (IL); **Nadav Geva**, Tel Aviv (IL); **Oded Gigushinski**, Herzlia (IL); **Ephraim Goldenberg**, Ashdod (IL)

(73) Assignee: **Corephotonics Ltd.**, Tel Aviv (IL)

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,305,180 B2 12/2007 Labaziewicz et al.
7,561,191 B2 7/2009 May et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 102982518 A 3/2013
WO 2013105012 A2 7/2013
(Continued)

OTHER PUBLICATIONS

International Search Report and Written Opinion issued in related PCT patent application PCT/IB2014/063393, dated May 11, 2016. 9 pages.
(Continued)

Primary Examiner — Amy Hsu
(74) *Attorney, Agent, or Firm* — Nathan & Associates; Menachem Nathan

(57) **ABSTRACT**

Dual-aperture digital cameras with auto-focus (AF) and related methods for obtaining a focused and, optionally optically stabilized color image of an object or scene. A dual-aperture camera includes a first sub-camera having a first optics bloc and a color image sensor for providing a color image, a second sub-camera having a second optics bloc and a clear image sensor for providing a luminance image, the first and second sub-cameras having substantially the same field of view, an AF mechanism coupled mechanically at least to the first optics bloc, and a camera controller coupled to the AF mechanism and to the two image sensors and configured to control the AF mechanism, to calculate a scaling difference and a sharpness difference between the color and luminance images, the scaling and sharpness differences being due to the AF mechanism, and to process the color and luminance images into a fused color image using the calculated differences.

3 Claims, 10 Drawing Sheets