



US010571644B2

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

(10) **Patent No.: US 10,571,644 B2**  
(45) **Date of Patent: Feb. 25, 2020**

(54) **FOLDED CAMERA LENS DESIGNS**

(71) Applicant: **Corephotonics Ltd.**, Tel-Aviv (IL)  
(72) Inventors: **Gal Shabtay**, Tel Aviv (IL); **Ephraim Goldenberg**, Ashdod (IL); **Michael Dror**, Nes Ziona (IL); **Itay Yedid**, Karme Yosef (IL); **Gil Bachar**, Tel Aviv (IL)

(73) Assignee: **Corephotonics Ltd.**, Tel Aviv (IL)  
(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/252,608**  
(22) Filed: **Jan. 19, 2019**

(65) **Prior Publication Data**  
US 2019/0170965 A1 Jun. 6, 2019

**Related U.S. Application Data**

(63) Continuation of application No. 16/077,477, filed as application No. PCT/IB2018/050988 on Feb. 18, 2018.  
(Continued)

(51) **Int. Cl.**  
**G02B 7/02** (2006.01)  
**H04N 5/225** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **G02B 7/021** (2013.01); **G02B 7/08** (2013.01); **G02B 13/004** (2013.01);  
(Continued)

(58) **Field of Classification Search**  
CPC .. G02B 13/0065; G02B 7/021; G02B 13/004; H04N 5/2259  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,106,752 A 2/1938 Land  
2,354,503 A 7/1944 Cox  
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101276415 A 10/2008  
CN 102739949 A 10/2012  
(Continued)

OTHER PUBLICATIONS

A Compact and cost effective design for cell phone zoom lens, Chang et al., Sep. 2007, 8 pages.  
(Continued)

*Primary Examiner* — William R Alexander  
*Assistant Examiner* — Ephrem Z Mebrahtu  
(74) *Attorney, Agent, or Firm* — Nathan & Associates; Menachem Nathan

(57) **ABSTRACT**

Digital cameras, optical lens modules for such digital cameras and methods for assembling lens elements in such lens modules. In various embodiments, the digital cameras comprise an optical lens module including  $N \geq 3$  lens elements  $L_i$ , each lens element comprising a respective front surface  $S_{2i-1}$  and a respective rear surface  $S_{2i}$ . In various embodiments the first lens element toward the object side,  $L_1$  and its respective front surfaces  $S_1$  have optical and/or mechanical properties, such as a clear aperture, a clear height and a mechanical height that are larger than respective properties of following lens elements and surfaces. This is done to achieve a camera with large aperture stop, given a lens and/or camera height.

**24 Claims, 28 Drawing Sheets**

