



US009641731B2

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

(10) **Patent No.:** **US 9,641,731 B2**
(45) **Date of Patent:** **May 2, 2017**

(54) **UNSTABLE MAGNETIC RELUCTANCE ACTUATOR**

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

(72) Inventors: **Ephraim Goldenberg**, Ashdod (IL); **Gal Avivi**, Haifa (IL); **Gil Bachar**, Tel-Aviv (IL); **Yehonatan Mandel**, Kiryat-Ata (IL); **Itay Yedid**, Karme Yosef (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.: **15/081,889**

(22) Filed: **Mar. 27, 2016**

(65) **Prior Publication Data**

US 2016/0337590 A1 Nov. 17, 2016

Related U.S. Application Data

(60) Provisional application No. 62/161,474, filed on May 14, 2015.

(51) **Int. Cl.**
H04N 5/225 (2006.01)
H02K 33/00 (2006.01)
G02B 27/64 (2006.01)

(52) **U.S. Cl.**
CPC **H04N 5/2251** (2013.01); **G02B 27/646** (2013.01); **H02K 33/00** (2013.01); **H04N 5/2253** (2013.01); **H04N 5/2254** (2013.01); **H04N 5/2257** (2013.01)

(58) **Field of Classification Search**

CPC .. H04N 5/2251; H04N 5/2257; H04N 5/2253; H04N 5/2254; H02K 33/00; G02B 27/646
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|------------------|---------|-------------------|--------------------------|
| 8,731,390 B2 | 5/2014 | Goldenberg et al. | |
| 2010/0232161 A1* | 9/2010 | Aschwanden | G02B 3/14 362/278 |
| 2013/0128099 A1* | 5/2013 | Gutierrez | G02B 7/08 348/349 |
| 2014/0063331 A1* | 3/2014 | Goldenberg | G03B 3/10 348/357 |
| 2014/0333829 A1* | 11/2014 | Lee | H04N 5/2251 348/373 |
| 2015/0318772 A1* | 11/2015 | Jahshan | H02P 23/00 318/400.41 |

(Continued)

FOREIGN PATENT DOCUMENTS

WO PCT/IB2014/062836 A1 5/2015

Primary Examiner — Shahbaz Nazrul

(74) *Attorney, Agent, or Firm* — Nathan & Associates
Patent Agents Ltd; Menachem Nathan

(57) **ABSTRACT**

A magnetic reluctance actuator (MRA) comprising an unstable magnetic reluctance motor (MRM) having a strong force-to-position dependency and a nonlinear force-to-current dependency, the unstable MRM operative to move a lens carrier in a given direction, a lens position sensing mechanism, and a control unit configured to obtain an input from the position sensing mechanism and to provide closed loop control to overcome the strong force-to-position dependency and the nonlinear force-to-current dependency, thereby allowing precise lens position control.

7 Claims, 4 Drawing Sheets

120

