US009409763B2

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

(10) **Patent No.: US 9,409,763 B2**
(45) **Date of Patent: Aug. 9, 2016**

(54) **MEMS DEVICE AND METHOD OF MAKING A MEMS DEVICE**

(75) Inventors: **Alfons Dehe**, Reutlingen (DE); **Martin Wurzer**, Munich (DE); **Christian Herzum**, Starnberg (DE)

(73) Assignee: **Infineon Technologies AG**, Neubiberg (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 435 days.

(21) Appl. No.: **13/439,729**

(22) Filed: **Apr. 4, 2012**

(65) **Prior Publication Data**

US 2013/0264663 A1 Oct. 10, 2013

(51) **Int. Cl.**

H04R 19/04	(2006.01)
B81B 3/00	(2006.01)
H04R 19/00	(2006.01)
H04R 7/06	(2006.01)

(52) **U.S. Cl.**

CPC ***B81B 3/007*** (2013.01); ***B81B 3/0035*** (2013.01); ***B81B 3/0051*** (2013.01); ***H04R 19/005*** (2013.01); *B81B 2201/0257* (2013.01); *H04R 7/06* (2013.01); *H04R 19/04* (2013.01)

(58) **Field of Classification Search**

CPC ... B81B 3/0035; B81B 3/0051; H04R 19/005
USPC 257/416
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,870,482	A *	2/1999	Loeppert et al.	381/174
6,168,906	B1	1/2001	Bernstein et al.	
6,441,451	B1	8/2002	Ikeda et al.	
6,756,248	B2	6/2004	Ikeda et al.	
7,153,717	B2 *	12/2006	Carley et al.	438/55
8,072,010	B2 *	12/2011	Lutz	B81B 3/0072 257/254
8,103,027	B2 *	1/2012	Zhang	H04R 1/222 381/175
8,104,354	B2 *	1/2012	Hsu	G01L 9/0073 29/592.1
8,121,315	B2 *	2/2012	Song	H04R 19/005 381/113
8,126,167	B2 *	2/2012	Hirade	H04R 19/005 381/174
8,345,895	B2 *	1/2013	Chen	B81B 3/0078 257/416
8,553,911	B2 *	10/2013	Chen	B81B 3/0078 257/416
2001/0038148	A1	11/2001	Mastromatteo et al.	
2004/0106294	A1	6/2004	Lee et al.	
2005/0078349	A1	4/2005	Patel et al.	
2005/0241944	A1 *	11/2005	Dehe et al.	205/75

(Continued)

FOREIGN PATENT DOCUMENTS

CN	1260796	C	6/2006
CN	101426718	A	5/2009

(Continued)

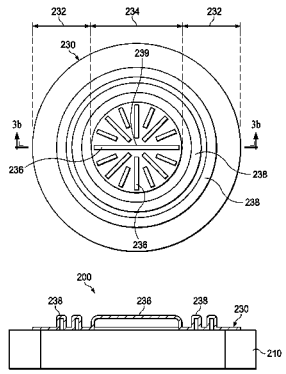
OTHER PUBLICATIONS

Kaiser, T et al., "Silicon Nitride Biaxial Pointing Mirrors with Stiffening Ribs," MOEMS and Miniaturized Systems II, Proceedings of SPIE vol. 4561, Oct. 2, 2001, pp. 276-282.

(Continued)

Primary Examiner — Evan Pert
(74) *Attorney, Agent, or Firm* — Slater & Matsil, L.L.P.

(57) **ABSTRACT**

A MEMS device and a method of making a MEMS device are disclosed. In one embodiment a semiconductor device comprises a substrate, a moveable electrode and a counter electrode, wherein the moveable electrode and the counter electrode are mechanically connected to the substrate. The movable electrode is configured to stiffen an inner region of the movable membrane.

27 Claims, 17 Drawing Sheets