US009411097B2

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

(10) **Patent No.: US 9,411,097 B2**
(45) **Date of Patent: Aug. 9, 2016**

(54) **OPTICAL MODULE**

(71) Applicant: **ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE**, Daejeon (KR)

(72) Inventors: **Young Tak Han**, Daejeon (KR); **Sang Ho Park**, Daejeon (KR); **Yong Soon Baek**, Daejeon (KR); **Jang Uk Shin**, Daejeon (KR)

(73) Assignee: **ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE**, Daejeon (KR)

(*) 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.: **14/727,751**

(22) Filed: **Jun. 1, 2015**

(65) **Prior Publication Data**

US 2016/0154177 A1 Jun. 2, 2016

(30) **Foreign Application Priority Data**

Nov. 27, 2014 (KR) 10-2014-0167781

(51) **Int. Cl.**
G02B 6/12 (2006.01)
G02B 6/36 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 6/12*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,036,505 B2 * 10/2011 Hasegawa G02B 6/1203 385/14
8,798,409 B2 * 8/2014 Pardo H04B 10/506 385/129

(Continued)

FOREIGN PATENT DOCUMENTS

KR 10-2007-0042966 A 4/2007
KR 10-1430634 B1 8/2014

OTHER PUBLICATIONS

T. Fujisawa et al., "Ultracompact, 160-Gbit/s transmitter optical sub-assembly based on 40-Gbit/s×4 monolithically integrated light source", Optics Express, vol. 21, No. 1, pp. 182-189, Jan. 14, 2013.

(Continued)

Primary Examiner — Hemang Sanghavi
(74) *Attorney, Agent, or Firm* — Rabin & Berdo, P.C.

(57) **ABSTRACT**

Provided herein is an optical module including an optical bench having a first step with a first depth and a second step with a second depth that is smaller than the first depth; a silicon carrier disposed above the first step, and where at least one semiconductor chip is installed; an AWG chip (Arrayed Waveguide Grating chip) secured to the second step, extends up to the first step, and is chip-to-chip bonded with the silicon carrier above the first step; a lens disposed on an upper surface of the optical bench where the first step and the second step are not formed; and a metal package surrounding the optical bench, silicon carrier, AWG chip and lens, wherein at one side of the metal package, a double slit that includes an upper slit and a lower slit are formed, a DC FPCB (Direct Current FPCB) extends from outside towards inside the metal package through the upper slit and is secured to a support formed on an inner surface of the upper slit, and an RF FPCB (Radio Frequency FPCB) extends from outside towards inside the metal package through the lower slit and is secured to an upper portion of the silicon carrier, and the upper slit and the lower slit of the double slit being sealed by an elastic epoxy.

20 Claims, 3 Drawing Sheets