


Optical Components and Modules



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E-mail : choi@lumicle.com

History of...

■ **Jae-Shik, Choi Ph.D. : CEO of LUMICLE**

- 1998. 01 ~ 2001. 05 : ETRI (Electronic and Telecommunications Research Institute of KOREA)
: Samsung Electronics (Fiber Optics Div.)
- 2001. 05 ~ 2013. 07 : Director of Fiber Optics Div. & R&D center in Hantech Co., Ltd.
- 2013. 10 ~ : CEO of LUMICLE Co., Ltd.,

■ **Products development**

- Angle Polished Fiber Array Blocks (FAA) : Q4/2001
- Monitor-PD Integrated Fiber Array Module (FMA): Q4/2002
- Collimated Fiber Array Blocks (FAC): Q1/2003
- Channel Monitoring Module (FMT & E): Q4/2005 → Telcordia Certified at 2Q/2006
- Micro Lens fiber array (FAC): Q3/2009
- Optical Line Checker: Q3/2010
- 1xN Optical Switch: Q1/2011
- Expanded Beam Connector: Q2/2013

■ **Patents**

- Register 8 Patents in Domestic & Overseas → 현재 국내외 총 4개 특허만 유지중

■ **LUMICLE Certifications**

- 2016. 05. 25 : R&D Center Established
- 2016. 06. 30 : Venture Company Certification

Production line and facility



Line view 1



Line view 2



CA assy line : (2 sets)



Core pitch and 3D profiler



Wire bonder



V-groove machining Equipment



FA assy line (8 sets)



Measurement system (3 sets)



Reliability, MCs



Dicing MC



Flip-chip bonder : 3 systems



Microscope (x1000)



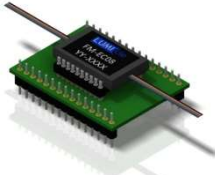
Wet bench / Oven



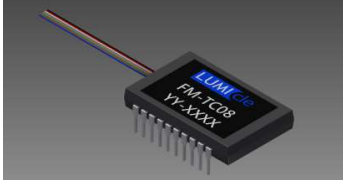
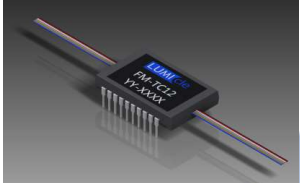
Polishing line (4 sets)

- Line 1 (실 100평) : FA & FM
- Line 2 (실 50평) : FCB (Clean booth) & 연구소
- 총 Set-up 비용 : ~ 30억원

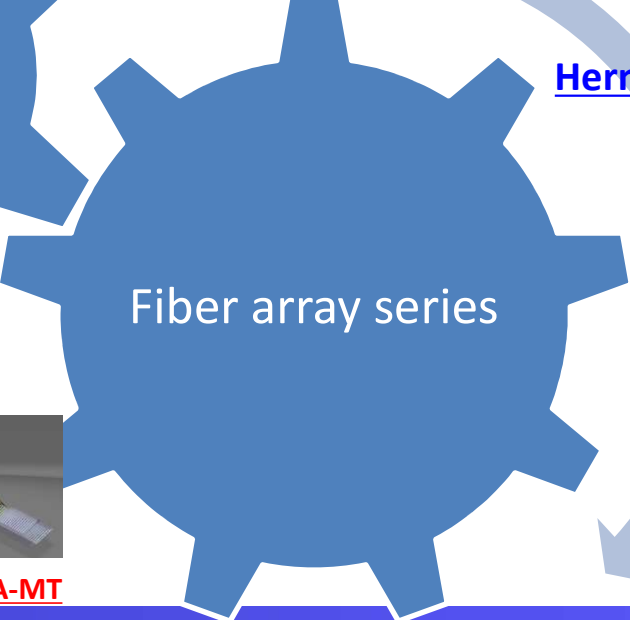
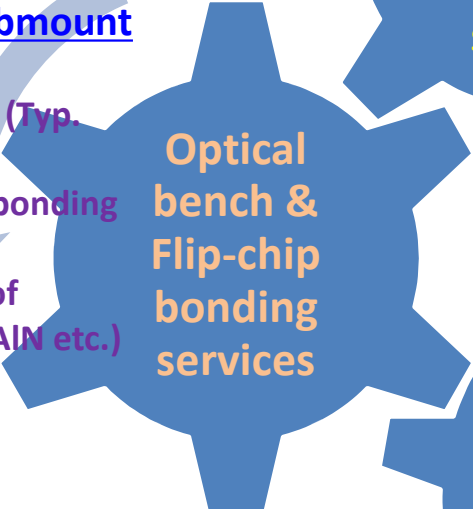
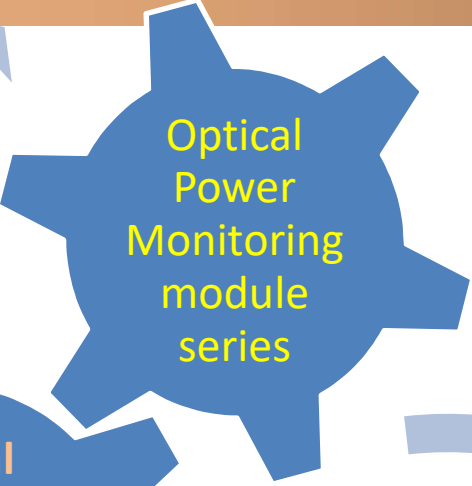
Business Portfolio



FMEC

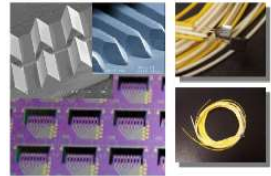


FMTC



OEM service for FCB & Submount

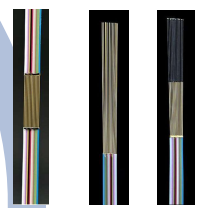
- Flip-chip bonder : 3 systems
- Bonding accuracy : < 1.5 um (Typ. < 1.0 um)
- Available for multi channel bonding by using discrete chip
- Available for custom made of submount (SiOB, Glass and AlN etc.)



Optical connector series

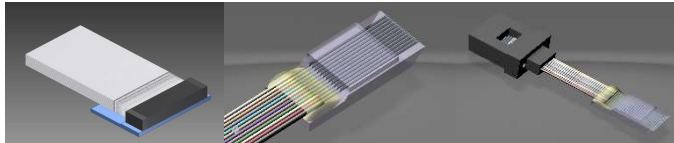
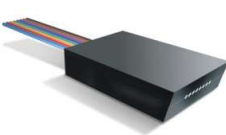
- SC, FC, LC, MT/MP etc.

Hermetic components



Metallized fiber

Fiber Arrays



3D FA

45 deg. FA

45 deg. FA-MT



KOVAR feed-through

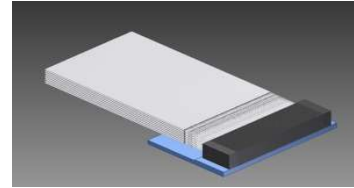
Fiber Array Series



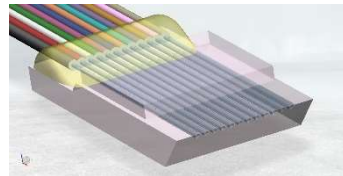
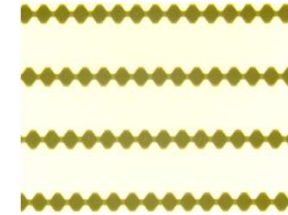
FIBER ARRAYS



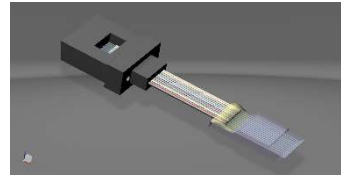
STANDARD



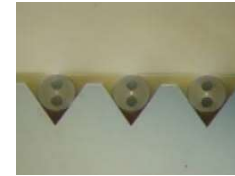
MULTI-LAYER (1530 FIBER)



45 deg. POLISHED



45 deg. FA-MT



PM FA



FA with Feed through

FEATURES

- Creative and practical fiber arrays with functionality
- Excellent accuracy of fiber core position
- Low insertion loss and high reliability
- Si & glass based fiber array available
- PD integrated fiber array for optical power monitoring
- Available for PM fiber array by customization
- AR coating available

제품 분석 및 향후 전망 (FA 제품군)

Fiber Array (FA)

□FA : 광모듈에서 광소자-광섬유, 광섬유-광섬유간 광접속 등 광전송에 필수적인 부품.

□응용분야 : 전반적인 광통신용 모듈 및 시스템의 필수 부품

□기술성 및 독창성 : 국내 경쟁사 없음.

□20년간 축적된 경험에 기반한 고신뢰성, 고정밀도를 갖는 FA 제작 기술을 보유함.

□이러한 기술을 바탕으로 인쇄회로 기판 노광기에 사용되는 다층형 FA (1530채널, 10층) 개발 및 생산함.

□Nachi MC : FA용 V-groove 가공 설비로서, 국내에서는 유일하게 자사에서만 보유 →고객 맞춤형 특수사양 제작에 절대적인 경쟁력을 가짐.

□시장 현황 및 진입가능성 : 저가의 중국산에 밀려 국내의 FA 전문 제조 업체는 루미클만 생존.

□지난 10여년간 일부 특수 사양이나 고품질이 요구되지 않는 경우 대부분 저가의 중국산 사용.

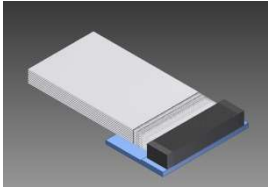
□그러나, 최근 저가 제품의 품질 및 신뢰성 문제, 특히 24채널 이상의 다채널 FA에서 불량률 급격히 증가 → 모듈의 제조원가 상승 및 신뢰도 하락 → 고품질 FA 필요성 절실 → 루미클 제품 선택 : 최근 3~4개 업체와 공급 협의중

□FA-05QQ : 100G TOSA 적용 제품, 고객 맞춤형으로서 2014년 부터 월 0.5~1K 양산중인 제품임.

□FA-24PP : 국내 5G 용 AWG 모듈 적용 제품, 초기 중국 제품을 사용하다가 최근 루미클에서 공급함.

□FA-48QQ : WSS ROADM 적용 제품, 중국산의 품질 문제로 최근 루미클 제품으로 변경.

□Feed through : Metallized fiber & KOVAR soldering 제품으로, 광모듈의 Hermetic sealing 을 위한 부품 → 일본 제품이 주를 이루었으나, 최근 한일 무역분쟁의 영향으로 국내 업체의 개발 요청으로 개발 완료.

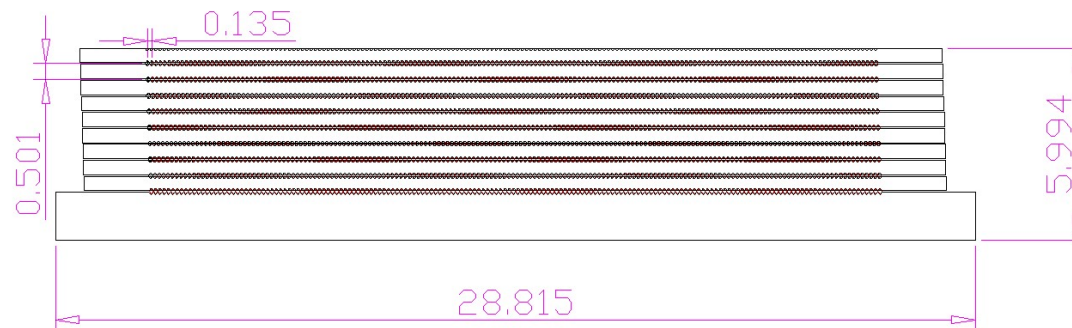


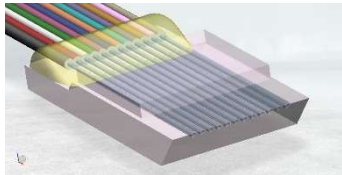
Specifications for FAA



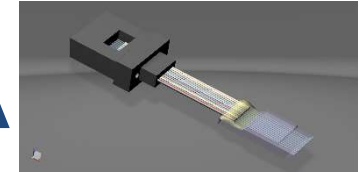
| Parameters | Unit | Specifications | Remarks |
|--------------------|------|---------------------------------------|--|
| Number of Channel | port | ~ 1530 (10 layers) | Available for customization and multi layers |
| Materials | | Silicon, Pyrex (Py), Quartz (Qz) | Available for customization |
| Insertion Loss | dB | < 0.5 | |
| Return Loss | dB | > 50 | @ angle polished |
| Core pitch / Error | um | 127 ~ 250 / ± 0.5 (Si), ± 0.7 (Py,Qz) | Available for customization (Machine shop in house) |
| Polishing Angle | deg. | Standard : 0, 8, 12 (± 0.3) | Available for customization |
| Connector Type | | LC, SC, FC | Available for customization |
| Operating Temp. | °C | -10 ~ +70 | |
| Storage Temp. | °C | -40 ~ +85 | |

1530 ch (10 layers)

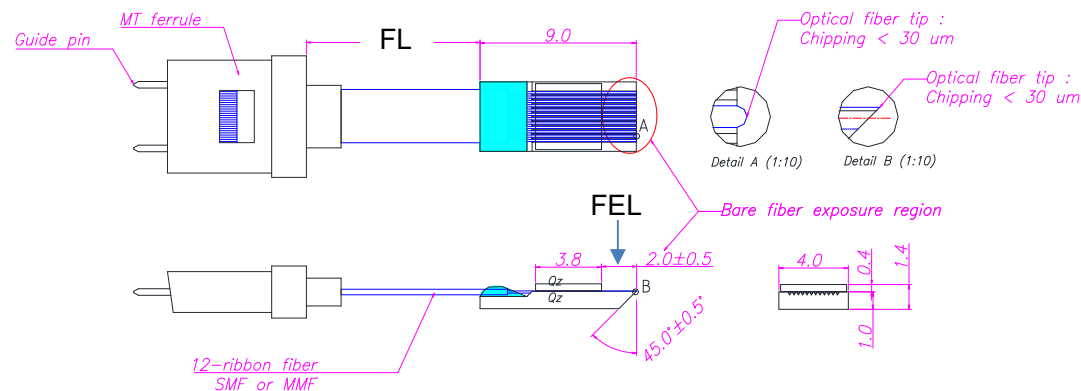
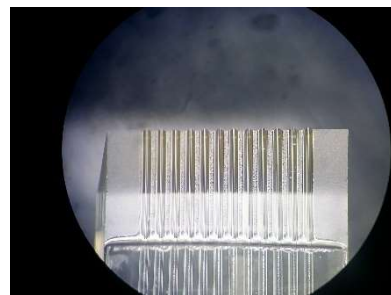




Specifications for 45 deg. FAA



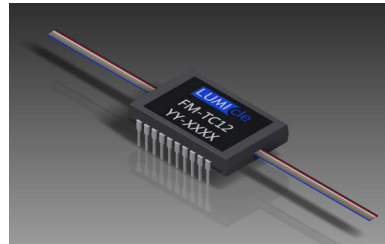
| Parameters | Specification | Remarks |
|-----------------------------|---|---------------------------------|
| Fiber type | SMF & MMF | |
| Number of Channels | 12 ch. | Customized |
| Material (Lid/Substrate) | Quartz/Quartz | Available for Pyrex and Silicon |
| Fiber Exposure Length (FEL) | 2 mm | Customized |
| Fiber Length (FL) | 10 ~ 20 mm | Available for less than 10 mm |
| Insertion Loss | Max 0.7 dB (Typ. ~ 0.3 dB) | Included Connector |
| Polishing Angle | 45° (± 0.5°) | Customization available |
| Connector | MT ferrule | Available for Premium grade |
| Dimensions | 4.0(W) x 9.0(L) x 1.4(H) mm ³ for standard 12 channel | Customization available |



Channel Monitoring Module

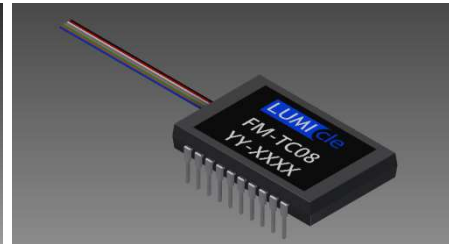
CHANNEL MONITORING MODULE

FME



IN LINE (TAP) TYPE

FMT



TERMINAL TYPE

FMA

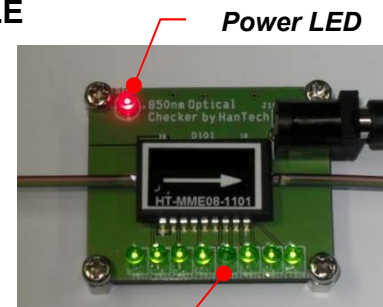


TERMINAL & TAP MONITORING MODULE

- Ultra compact optical channel monitoring module
- Uniform monitoring power and high sensitivity
- High reliability (certified Telcordia)
- User friendly chip design

OPTICAL CHECKER

- Real-time monitoring of datacom & telecom system
- Convenient LED indication for active lines
- Low insertion loss : < 1.0 dB (Typ. 0.5 dB)
- Wide dynamic range & low power consumption
- Compact size : 4.3cm x 3.5cm x 3cm



Dead line

OPTICAL CHECKER

제품 분석 및 향후 전망 (FM 제품군)

Optical Monitoring Module

□ 광섬유어레이에 직접 array PD를 집적하여 광신호의 세기를 측정하는 모듈

□ 응용분야 : 광통신 시스템의 선로 감시용 모듈

□ 기술성 및 독창성 : 타사 제품에 비해 1/3 크기, 특허출원 (국내/해외)

□ 경쟁사 제품에 비해 공간활용도 및 가격경쟁력면에서 우수함.

□ 시장 현황 및 진입가능성

□ 대상 고객 : 국내외 통신서비스 업체 및 통신시스템 제조 업체 (KT, SKT, LG 및 Huawei, JDSU 및 기타 모듈 업체 등)

□ 기존 시장 : 통신캐비닛의 공간적 제한이 적어 복수개의 single tap PD를 이용하였음.

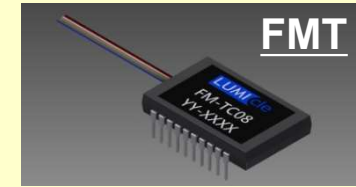
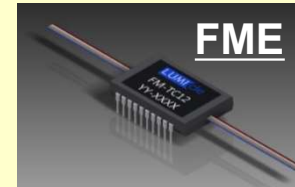
□ 한 보드내 수용 채널 수 증가 → 경박단소의 부품이 필수적임.

□ 가격 경쟁력 : 고가의 부품들로 구성된 기존 single tap PD에 비해 약 60% ~ 수준의 제조원가


□ 기술력 / 생산성 : 2004년 개발 완료 → 2007년 부터 Enablence(미)에 양산 납품하였으나 고객사 사업축소로 중단됨.

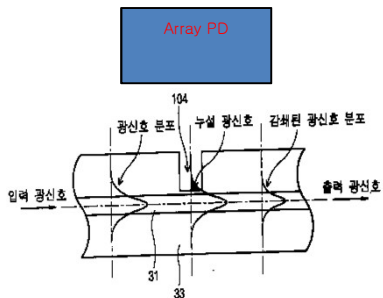
□ 2018년 : Huawei(중)에 데이터센터용 네트워크장비용으로 샘플 150세트 납품하여 최종 테스트 중 → 양산 전환 예정.

□ 또한, 향후 해당 제품을 이용하여 Hand held 파장광측정기 등 여러 형태의 측정장치 개발도 가능함.



FME 경쟁사

| Company | 루미클 | Santec | JDSU | Oplink | Lightwave | O-net | Accelink | |
|---------|---|---|--|---|---|---|---|---------|
| 제품 사진 |  |  |  |  |  |  |  | |
| 크기 (mm) | 1ch | φ3.5 x 21 | φ3.2 x 18.5 | φ3.3 x 22 | φ3.5 x 18.1 | φ3.2 x 16 | φ3.0 x 22 | |
| | 4ch | 14.2x23x3.5 | 17.5x32x6 | - | 17.5x32x6 | 16.4x32x6 | - | |
| | 8ch | | 31x32x6 | 32x32.5x6 | 39x33x6 | 31x32x6 | 32x3 2.5x6 | 31x33x6 |
| | 10ch | | 39x32x6 | - | - | - | - | - |
| | 16ch | | - | - | - | - | - | - |



□FME 장단점

□경박단소

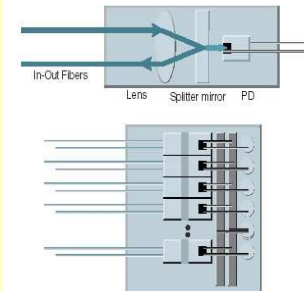
□낮은 제조원가 → 가격경쟁력

□높은 기술보안성 → 타사 기술 유출 위험이 매우 낮음.

□높은 신뢰성

□PCB 실장 등 후공정이 용이함.


□Directivity : ~ -7dB (개선중) → Filter 방식 : ~ -25 dB 까지 조절 가능(비용 상승)



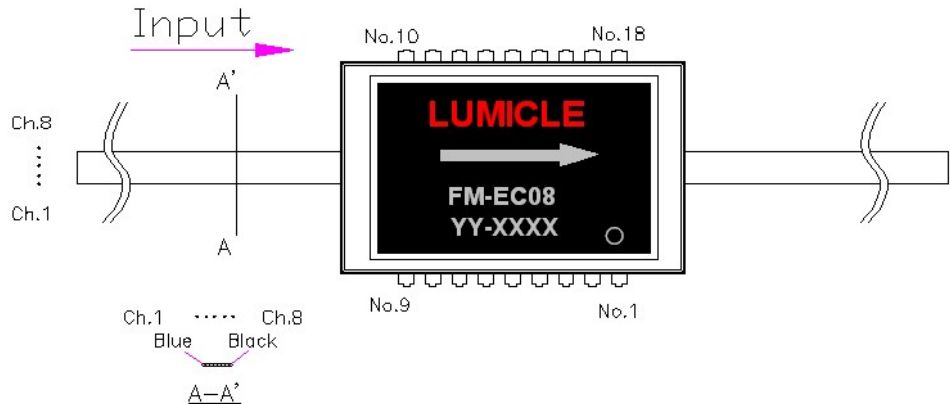
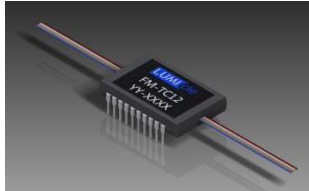
TELCORDIA Certifications

Issue number : 07-002-01

PAGE : (1 / 8)

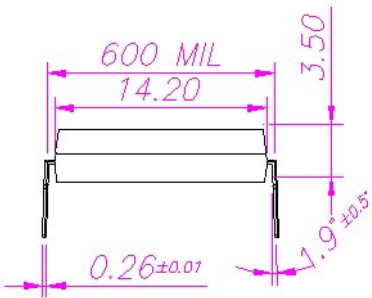
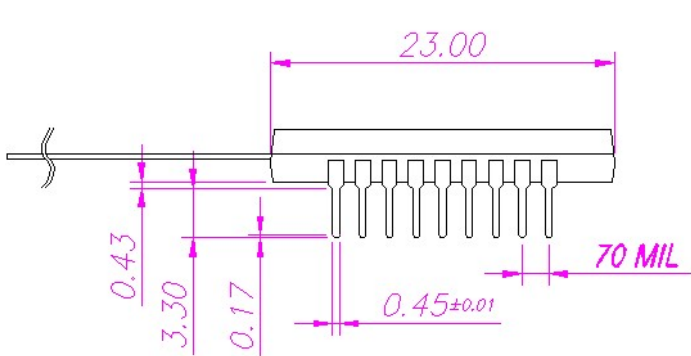
| | |
|---|----------------------|
|  | <h2>TEST REPORT</h2> |
| <p>1. Applicant Receipt No. : ETRI-OCR-06-082, 084, 085, 086, 088, 103, 104, 105, 190 Company Name : HANtech Applicant Address : 263-25, Gomae-Ri, Giheung-Eup, Yongin-Si, Gyeonggi-Do, Korea Representative : Han, Jong Hoon Receipt Date : May 15, 2006</p> | |
| <p>2. Use of Test Report : Reliability Verification</p> | |
| <p>3. Commodity/Quantity : FMT, 99 ea</p> | |
| <p>4. Test Items : ESD, Damp Heat Test, Low Temperature Storage Test, High Temperature Storage Test, Fiber Pull Test, Temperature Cycling Test, Mechanical Shock Test, Vibration Test, Thermal Shock Test</p> | |
| <p>5. Test Methods : Telcordia GR-468-CORE (2004)</p> | |
| <p>6. Test Date : June 23, 2006 – December 27, 2006</p> | |
| <p>7. Test Results : See Appendix</p> | |
| <p>Note : The test relates only for the samples provided by the applicant. Copies of this report are not valid.</p> | |
| <p>Testing personnel : Choi, Seung Nam, Technical Manager : Kang, Hyun Seo Yun, Kwang Sik, Lee, Jong Hyeon</p> | |
| <p>This test report is accredited by A2LA (American Association for Laboratory Accreditation) in U.S.A.</p> | |
| <p>January 18, 2007</p> | |
| <p>ETRI Optical Communications Research Center</p> | |
| <p>1110-6 Oryong-dong, Buk-gu, Gwangju, Korea +82-62-970-6100</p> | |

FMEC Series



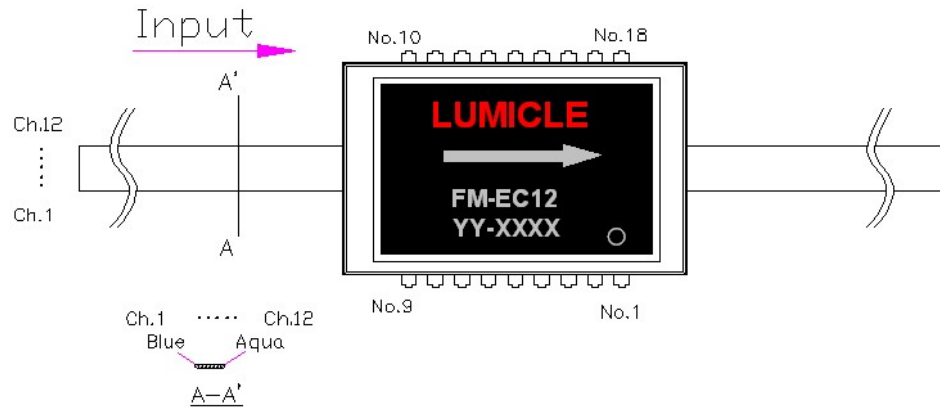
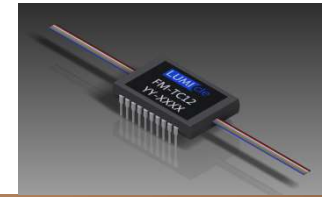
| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.1 | - |
| - | No.2 | - |
| Brown | No.3 | Ch. 4 |
| Green | No.4 | Ch.3 |
| Orange | No.5 | Ch.2 |
| Blue | No.6 | Ch.1 |
| - | No.7 | - |
| - | No.8 | - |
| - | No.9 | Cathode |

| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.10 | Cathode |
| - | No.11 | - |
| - | No.12 | - |
| Black | No.13 | Ch.8 |
| Red | No.14 | Ch.7 |
| White | No.15 | Ch.6 |
| Gray | No.16 | Ch.5 |
| - | No.17 | - |
| - | No.18 | - |



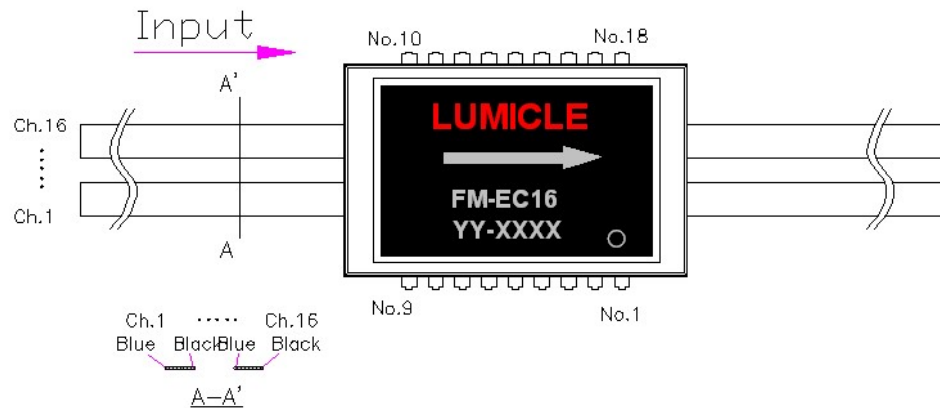
(Unit : mm)

FMEC Series – cont.



| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| | No.1 | |
| White | No.2 | Ch.6 |
| Gray | No.3 | Ch.5 |
| Brown | No.4 | Ch.4 |
| Green | No.5 | Ch.3 |
| Orange | No.6 | Ch.2 |
| Blue | No.7 | Ch.1 |
| | No.8 | |
| - | No.9 | Cathode |

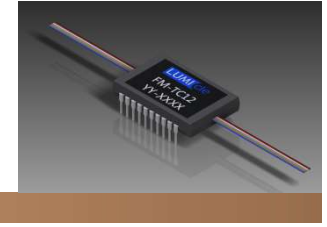
| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.10 | Cathode |
| | No.11 | |
| Aqua | No.12 | Ch.12 |
| Pink | No.13 | Ch.11 |
| Violet | No.14 | Ch.10 |
| Yellow | No.15 | Ch.9 |
| Black | No.16 | Ch.8 |
| Red | No.17 | Ch.7 |
| | No.18 | |



| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| Black | No.1 | Ch.8 |
| Red | No.2 | Ch.7 |
| White | No.3 | Ch.6 |
| Gray | No.4 | Ch.5 |
| Brown | No.5 | Ch.4 |
| Green | No.6 | Ch.3 |
| Orange | No.7 | Ch.2 |
| Blue | No.8 | Ch.1 |
| - | No.9 | Cathode |

| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.10 | Cathode |
| Black | No.11 | Ch.16 |
| Red | No.12 | Ch.15 |
| White | No.13 | Ch.14 |
| Gray | No.14 | Ch.13 |
| Brown | No.15 | Ch.12 |
| Green | No.16 | Ch.11 |
| Orange | No.17 | Ch.10 |
| Blue | No.18 | Ch.9 |

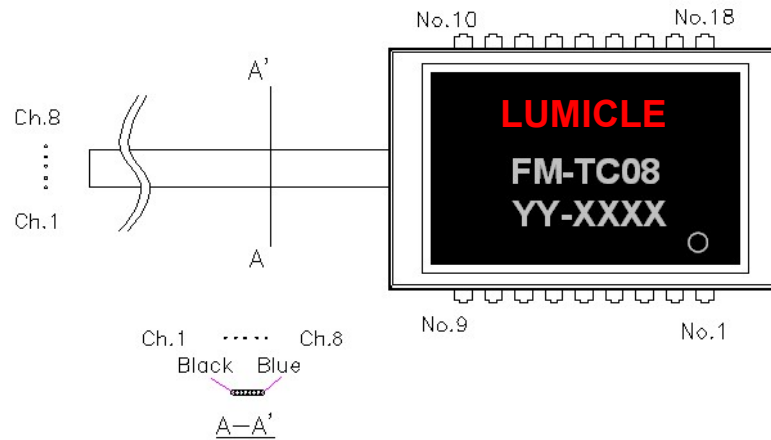
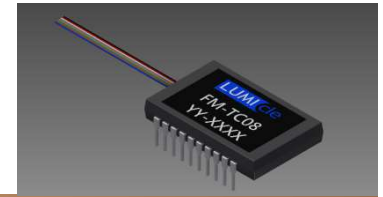
Specifications for FMEC



| Parameters | | Specification | | | Remarks |
|-----------------------|-----------------|---------------|-------------------|-------|-------------------------------------|
| | | 2 | 5 | 10 | |
| Number of Beams | | | 1 ~ 16 | | Standard : 8, 12, 16 |
| Insertion Loss | dB | < 0.6 | < 0.8 | < 1.0 | |
| Responsivity Range | mA/W | > 15 | > 30 | > 50 | |
| Dark Current | nA | | < 1.0 | | Typ. 0.2nA @ -5V, R.T |
| Adjacent Cross-talk | dB | | > 35 | | |
| Directivity | dB | | < -7 | | Between the upstream and downstream |
| Packaging Type | | | Dual in-line | | EMC molding case |
| Number of Pins | ea | | 18 | | |
| Pin Pitch | mil | | 70 | | |
| Dual in-line Pitch | mil | | 600 | | |
| Dimension (W x L x H) | mm ³ | | 14.2 x 23.0 x 3.5 | | |
| Operating Temperature | °C | | 0 ~ 70 | | |

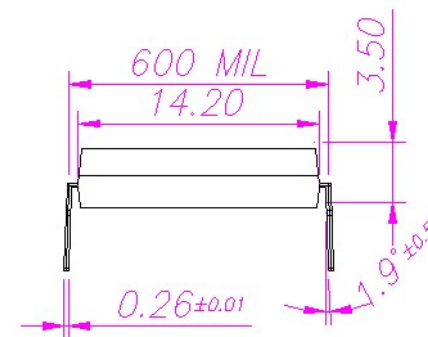
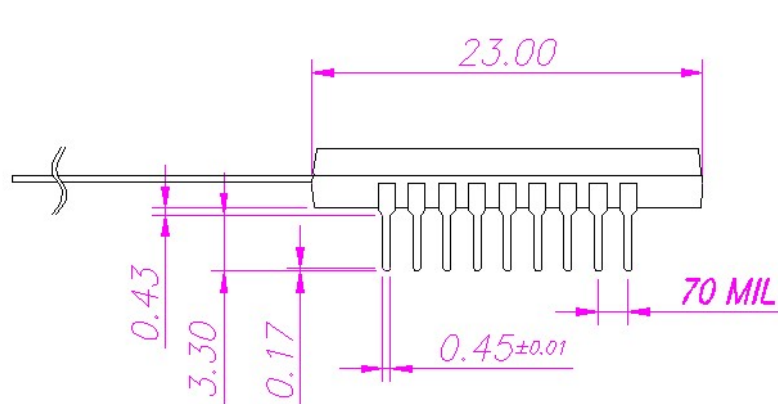
MPO connector available.

FMTC Series



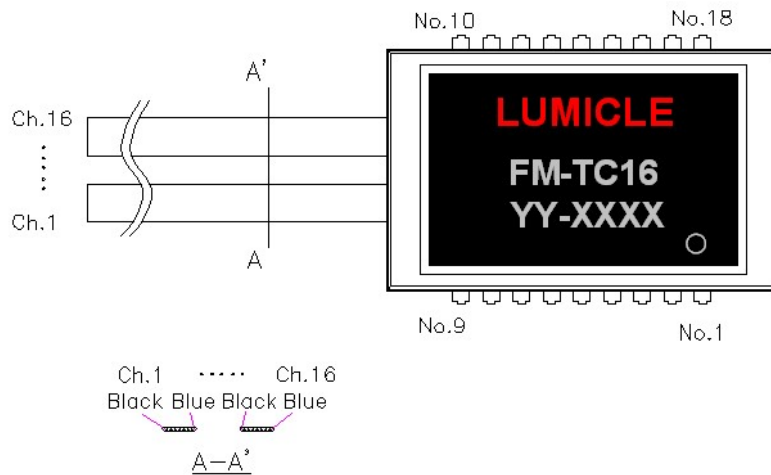
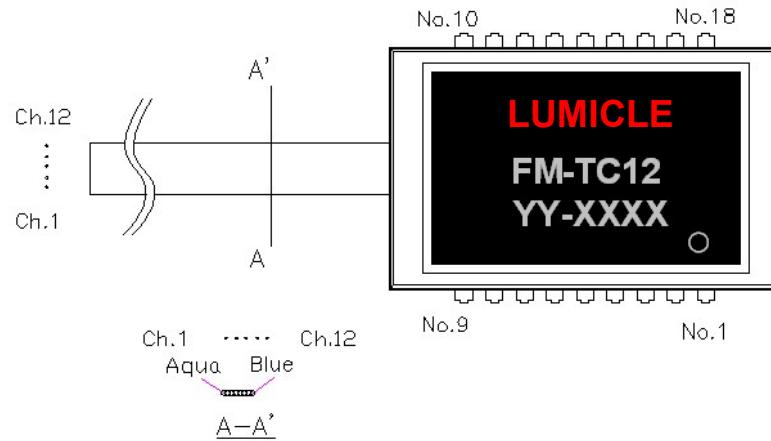
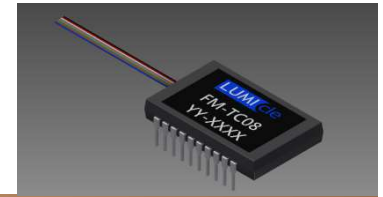
| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| | No.1 | Cathode |
| | No.2 | |
| | No.3 | |
| Black | No.4 | Ch.1 |
| Red | No.5 | Ch.2 |
| White | No.6 | Ch.3 |
| Gray | No.7 | Ch.4 |
| | No.8 | |
| - | No.9 | |

| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.10 | |
| | No.11 | |
| Brown | No.12 | Ch.5 |
| Green | No.13 | Ch.6 |
| Orange | No.14 | Ch.7 |
| Blue | No.15 | Ch.8 |
| | No.16 | |
| | No.17 | |
| | No.18 | Cathode |



(Unit : mm)

FMTC Series



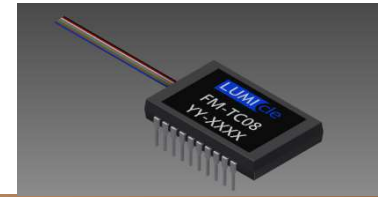
| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.1 | Cathode |
| - | No.2 | |
| Aqua | No.3 | Ch.1 |
| Pink | No.4 | Ch.2 |
| Violet | No.5 | Ch.3 |
| Yellow | No.6 | Ch.4 |
| Black | No.7 | Ch.5 |
| Red | No.8 | Ch.6 |
| - | No.9 | |

| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.10 | |
| White | No.11 | Ch.7 |
| Gray | No.12 | Ch.8 |
| Brown | No.13 | Ch.9 |
| Green | No.14 | Ch.10 |
| Orange | No.15 | Ch.11 |
| Blue | No.16 | Ch.12 |
| - | No.17 | |
| - | No.18 | Cathode |

| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.1 | Cathode |
| Black | No.2 | Ch.1 |
| Red | No.3 | Ch.2 |
| White | No.4 | Ch.3 |
| Gray | No.5 | Ch.4 |
| Brown | No.6 | Ch.5 |
| Green | No.7 | Ch.6 |
| Orange | No.8 | Ch.7 |
| Blue | No.9 | Ch.8 |

| Fiber Color | Pin No. | Assign |
|-------------|---------|---------|
| - | No.10 | Cathode |
| Blue | No.11 | Ch.16 |
| Orange | No.12 | Ch.15 |
| Green | No.13 | Ch.14 |
| Brown | No.14 | Ch.13 |
| Gray | No.15 | Ch.12 |
| White | No.16 | Ch.11 |
| Red | No.17 | Ch.10 |
| Black | No.18 | Ch.9 |

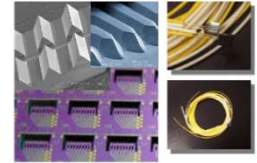
Specifications for FMTC



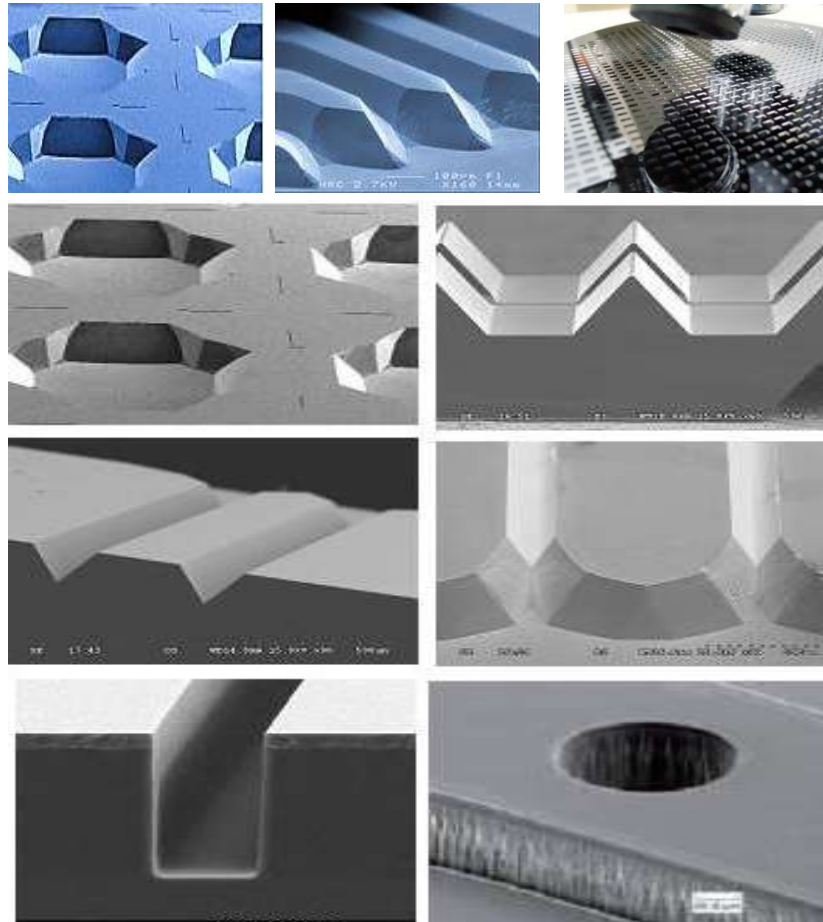
| Parameters | | Specification | Remarks |
|-----------------------|-----------------|-------------------|-----------------------|
| Number of Beams | | 1 ~ 16 | Standard : 8, 12, 16 |
| Responsivity | A/W | > 0.8 | |
| Dark Current | nA | < 1.0 | Typ. 0.2nA @ -5V, R.T |
| Adjacent Cross-talk | dB | > 35 | |
| Return Loss | dB | > 40 | |
| Packaging Type | | Dual in-line | EMC molding case |
| Number of Pins | ea | 18 | |
| Pin Pitch | mil | 70 | |
| Dual in-line Pitch | mil | 600 | |
| Dimension (W x L x H) | mm ³ | 14.2 x 23.0 x 3.5 | |
| Operating Temperature | °C | 0 ~ 70 | |

MPO connector available.

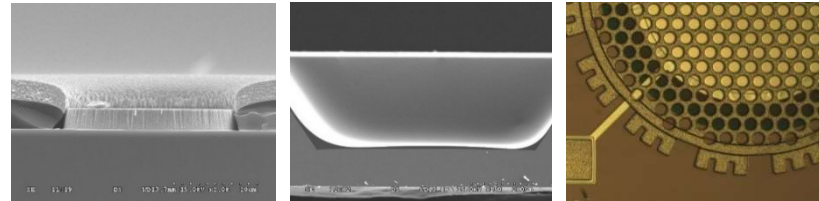
Optical bench & Si micro-machining



Micro-Machining & Mirror V-Groove for Optical

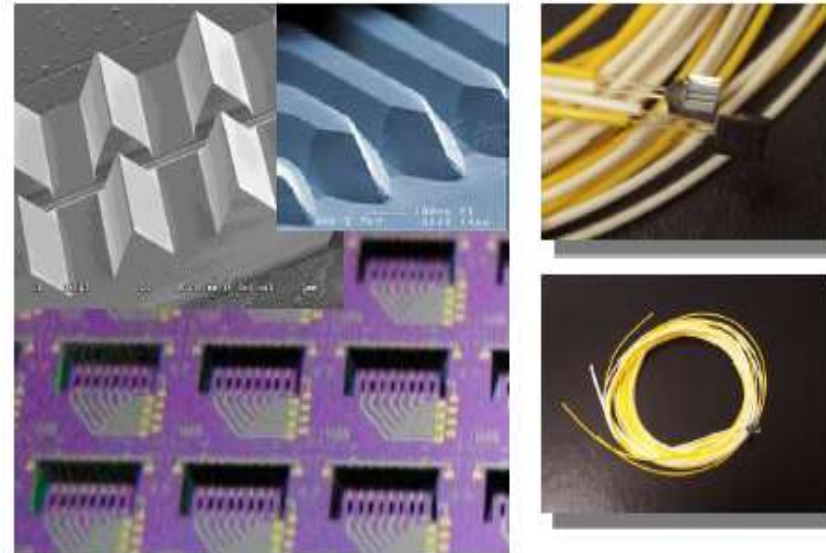


Metallization on 3D Structure (0.01um~10um)

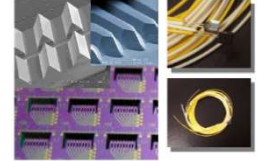


Silicon Submount for Optical Devices

- Metallization and Solder(AuSn) on 3D Structures
- Silicon and Al Nitride Substrate



Optical bench & Si micro-machining



Silicon Optical Bench (SiOB) 및 Flip-chip bonding (FCB)

□ SiOB : LD 및 PD용 광학벤치.

□ FCB : 상기 SiOB에 LD 및 PD 광소자 등을 1 um 이하의 정밀도로 솔더 본딩하는 기술.

□ 응용분야 : 모든 광통신 모듈용 부품 및 공정으로, 100G 이상의 고속 광모듈에 핵심 기술임.

□ 기술성 및 독창성 :

□ Si or glass 기판에 metal, etching, via hole, solder 등을 이용한 MEMS 설계 기술.

□ 전기적 광학적으로 우수한 특성의 기판 설계 및 제작(foundry 업체 이용) 가능.

□ FCB 기술은 재료 특성 등 기술적인 능력과 함께 경험적인 know-how가 핵심임 → 루미클은 20년 간의 축적된 FCB know-how를 바탕으로 전문업체로 평가 받고 있음.

□ 시장 현황 및 진입가능성

□ SiOB : 광모듈 업체의 요구에 따라 제작. 해외 업체는 가격이 국내의 수 배로 매우 높음.

□ FCB : 루미클은 국내 광통신 업체 중 유일한 FCB 전문 업체 → 5~6개 업체로 부터 월 1K~2K 정도 OEM 중.

□ 루미클 FCB 보유 댓수 : Finetech 람다 3대 (대당 2억원)

감사합니다