Guided-Wave, Electro-Optic Electric-Field Sensors utilizing Ti Diffused Lithium-Niobate ($Ti:LiNbO_3$) Optical Channel Waveguides

Hongsik Jung*
Dept. of Electronic & Electrical Convergence Engineering, Graduate School, Hongik University, Seoul, Korea
*hsjung@hongik.ac.kr

OUTLINE

• This paper comprehensively reviews and compares $Ti:LiNbO_3$ integrated optic electric-field sensors, including the asymmetric Mach-Zehnder interferometer (MZI), 1×2 directional coupler (DC), and 1×2 Y-fed balanced-bridge Mach-Zehnder interferometer (YBB-MZI), based on the operating principles, the dc/ac electrical and optical characteristics, and electric-field measurements for each fabricated device, respectively.

MOTIVATIONS

- The sensors provide improved measurement accuracy by reducing susceptibility to electrical noise because the sensors are made of dielectric materials (lithium niobate).
- The sensors provide a non-contact measurement of electric field.
- The sensors may be placed in hostile or remote areas because optical fibers are capable of transmitting light with high fidelity in noisy environments and over long distances.
- The sensors are electrically isolated, thus providing operator instrument safety.
- The sensors are small enough to be used where space is constraint.

$Ti:LiNbO_3$ CHANNEL WAVRGUIDE FABRICATION

– SENSOR FABRICATION PROCESSES

WAVEGUIDE, ELECTRODE DESIGN
PHOTOMASK FABRICATION
$LiNbO_3$ CUTTING, CLEANING
** WAVEGUIDE FABRICATION
EDGE POLISHING
LOSS MEASUREMENT
SiO2 BUFFER LAYER DEPOSITION
** ELECTRODE FORMATION
PIG TAILING
ANTENNA PACKING
SENSOR TEST

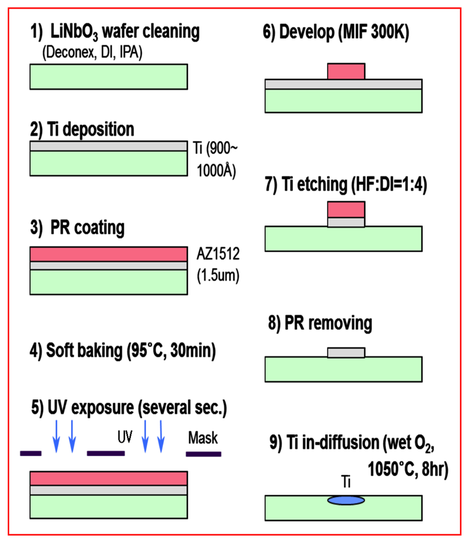
** Ti Wet etching
Ti Deposition
Photolithography
Waveguide Patterning
Ti-indifusion

** AL Deposition
Photolithography
Electrode Patterning
AL Etching

Input : PMF
Output : MMF

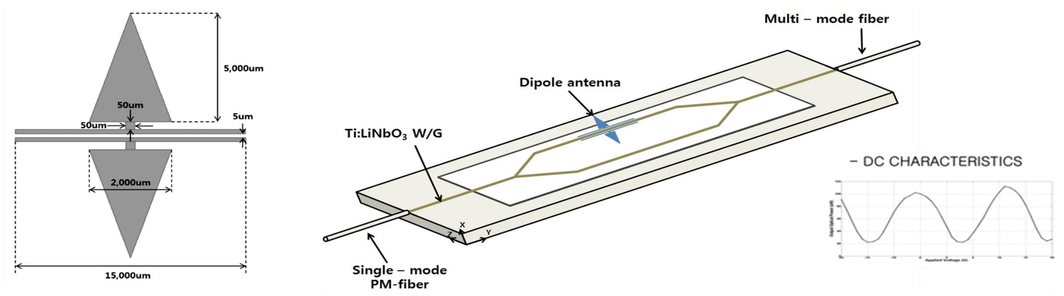
Epoxing
Antenna Connecting
Silver Bonding

– $Ti:LiNbO_3$ WAVEGUIDE FABRICATION

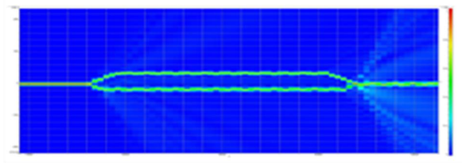


EXPERIMENTAL DATA for MZ with DIPOLE ANTENNA

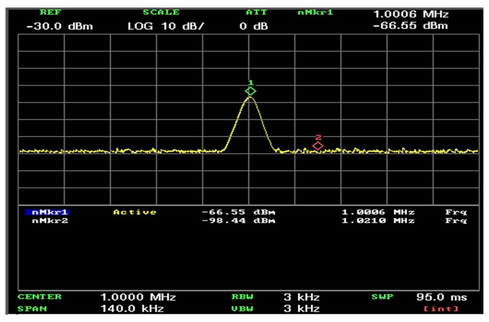
– SCHEMATIC LAYOUT of ELECTRIC-FIELD SENSOR



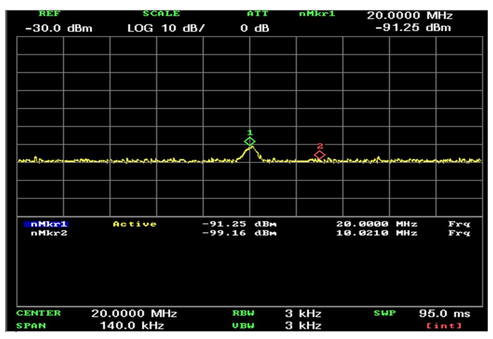
– 2D BPM SIMULATION



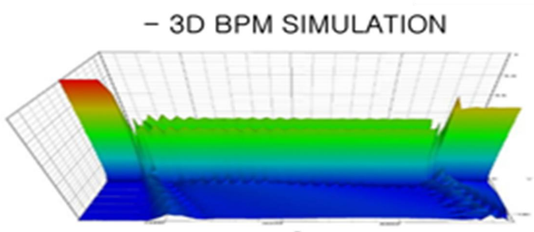
RF =1 MHz



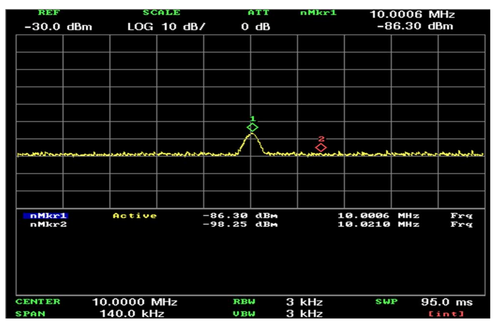
RF =20 MHz



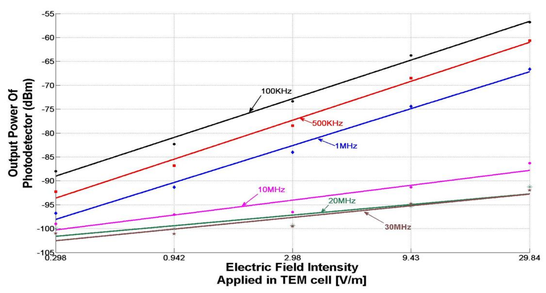
– 3D BPM SIMULATION



RF =10 MHz

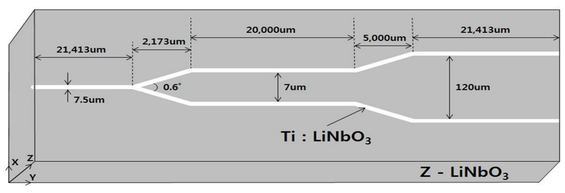


–SENSITIVITY

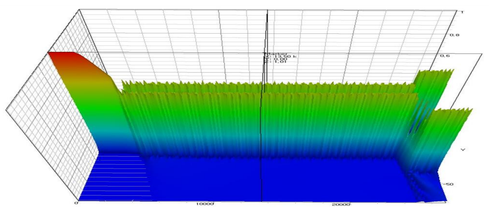


1x 2 DIRECTIONAL COUPLER

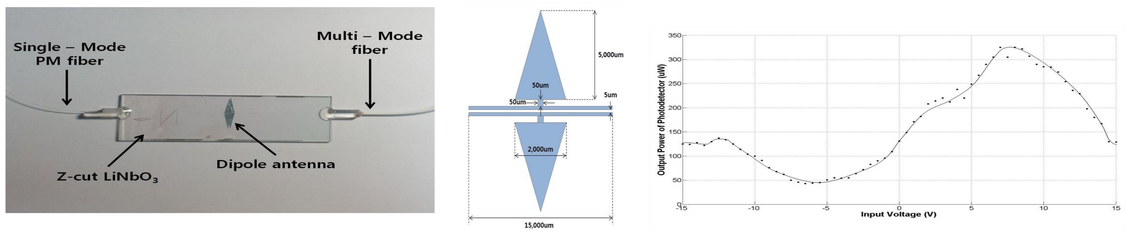
– DIRECTIONAL COUPLER LAYOUT



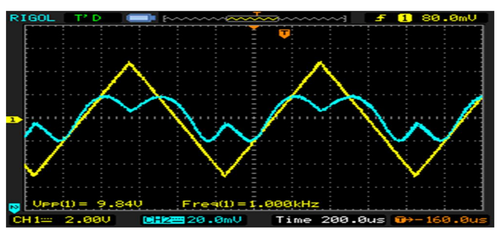
– 3D BPM SIMULATION



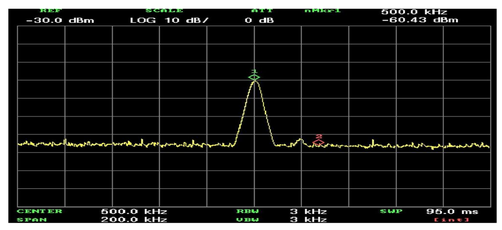
– DC CHARACTERISTICS



– OSCILLOSCOPE & RF SPECTRUM at 500KHz

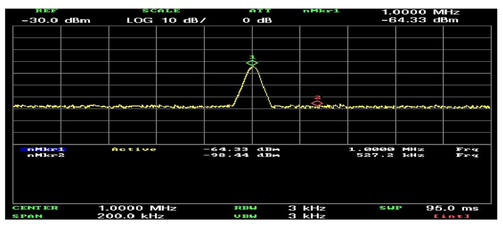


< Oscilloscope >

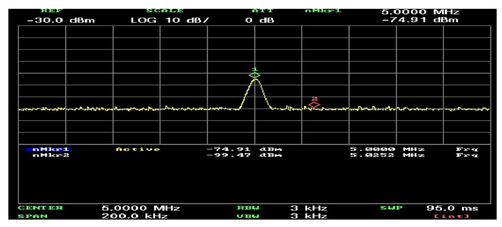


< 500KHz >

– SIGNAL AND NOISE LEVEL at RF SIGNAL 1MHz and 5MHz

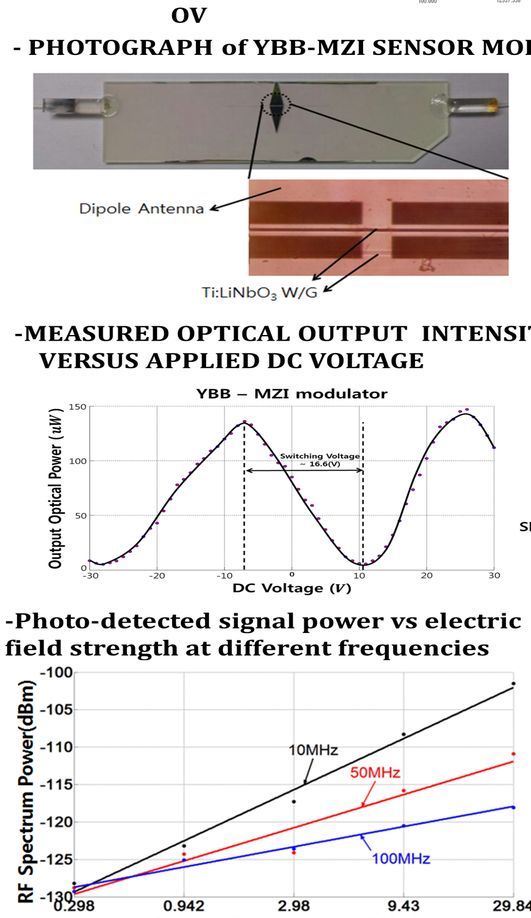


< 1MHz >



< 5MHz >

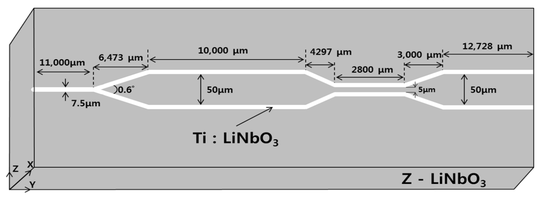
– FREQUENCY RESPONSE



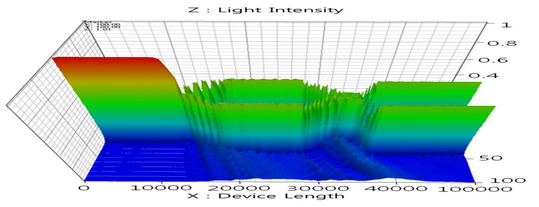
– SENSITIVITY

1X2 YBB MACH ZEHNDER INTERFEROMETER

– 1x2 YBB MZI MODULATOR LAYOUT



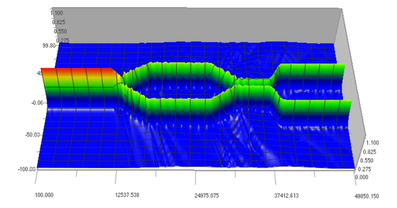
- 3D BPM SIMULATION



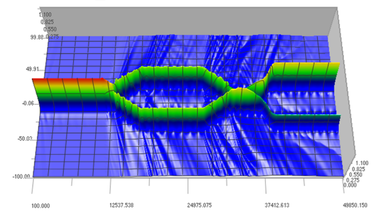
-The output power of the YBB-MZI modulator:

$$P_{01} = \frac{1}{2}[1 + sin(\pi y) \cdot sin(\pi x)] = \frac{1}{2}[1 + sin(2kL_c) \cdot sin(\Phi(E_e))]$$

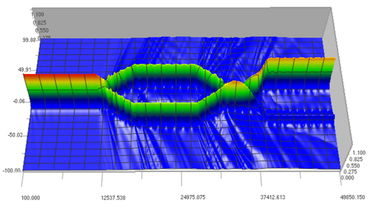
$$P_{02} = \frac{1}{2}[1 - sin(\pi y) \cdot sin(\pi x)] = \frac{1}{2}[1 - sin(2kL_c) \cdot sin(\Phi(E_e))]$$



OV

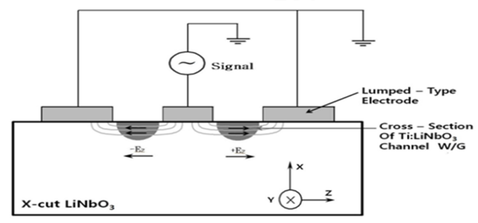


5V



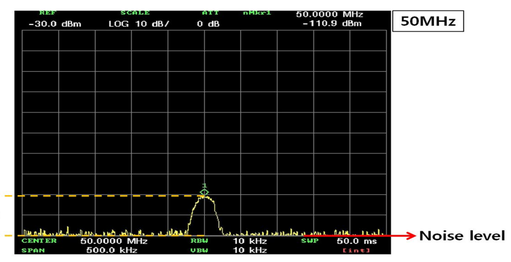
10V

- PHOTOGRAPH of YBB-MZI SENSOR MODULE

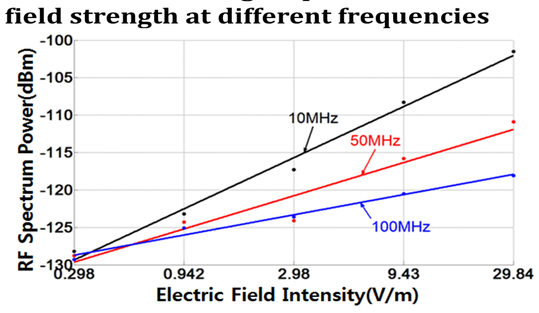


-MEASURED OPTICAL OUTPUT INTENSITY VERSUS APPLIED DC VOLTAGE

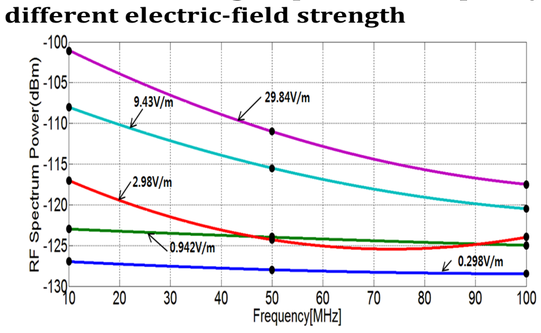
- RF SPECTRUM at 50 MHz



-Photo-detected signal power vs electric field strength at different frequencies



-Photodetected signal power vs frequency at different electric-field strength



21C Global leader
HONGIK UNIV
OPTOELECTRONICS LABORATORY