

# Unprecedented highest EO coefficient of 216 pm/V for electro-optic polymer/TiO<sub>2</sub> multilayer slot waveguide modulators

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## 1. Introduction

In conventional optical waveguide devices, an electro-optic (EO) active layer must be sandwiched between two layers that have low refractive-index with a similar EO active layer thickness. Our structure is composed of the same layers as an EO polymer/TiO<sub>2</sub> multilayer slot waveguide modulator [1] in order to measure an EO coefficient by Teng and Man technique. In standard structure, the EO polymer film is sandwiched between two electrodes and a voltage is applied between the electrodes to produce an electric field in the EO polymer films. As it is essential to have a higher voltage drop across the EO polymer layer, a barrier layers or a cladding layer that surrounds the polymer should have much higher conductivity than the EO polymer [2]. In order to achieve higher EO coefficient, and the role of interfaces between polymers, metal oxides and metals may be predominant.

## 2. Results and discussion

In this paper we will use EO/TiO<sub>2</sub>/sol-gel silica multilayer device for relatively thinner EO polymer. In contrary, for dual-layer barrier, one of the layers will be consider as a selective layer (SL) such as TiO<sub>2</sub>, which will allow higher distribution of the electric field dropped on the polymer, and the second layer will be a cladding layer (CL) such as sol-gel Silica. The objective of our study is to evaluate the charge transport in the SL and CL by J-V characteristic and electrical conductivity of each layer in the EO device structure. In the order to achieve higher EO coefficient, we need better optimization of the poling voltage applied across thinner guest-host EO polymer during the poling process. Our approach is to measure current density as a function of applied electric field at the poling temperature of 158°C for the device with EO polymers alone, that with just SL (TiO<sub>2</sub>), and that with TiO<sub>2</sub> and sol-gel CL (see fig. 1). This latter shows the J-V characteristic for SEO100 Polymer with and without TiO<sub>2</sub> SL, measured at 158°C. We observed that the TiO<sub>2</sub> layer protected slightly the EO polymer layer at low applied voltage (1.2 V). We observed that for the multilayer EO device with TiO<sub>2</sub> SL, the current density is greater than that without SL by two and three orders of magnitude. We can suggest that we have a better distribution of the electric field across the EO polymer with the presence of TiO<sub>2</sub> in the EO device structure. We found the EO coefficient of 5 and 3 pm/V (see #1 and #2 in table 1), with and without TiO<sub>2</sub>, respectively, because the

poling voltage is limited and the dielectric breakdown frequently happened. However, in the EO multilayer structure (see #3 in table 1) with TiO<sub>2</sub> SL and sol-gel CL, the EO coefficient of 216 pm/V and 184 pm/V was achieved for 380-nm-thick EO polymer, SEO100 at a wavelength of 1.31 and 1.55 μm, respectively, which reveals a better polarization of chromophore in the EO polymer film.

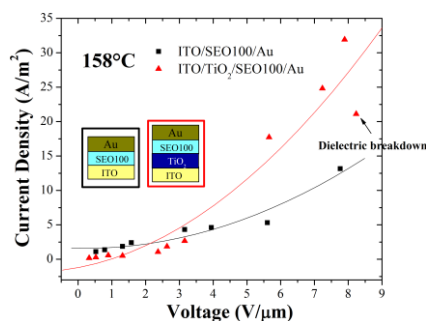


Fig. 1. Current density as function of poling voltage for EO device.

Table I Electro-optic parameters for SEO100 Polymer

Device	$I_m$ (mV)	$V_m$ (V)	$r_{33}$ (Pm/V) @1550nm
#1 ITO/SEO100/Au	1.4	30	5.9
#2 ITO/TiO <sub>2</sub> /SEO100/Au	1	30	3.2
#3 ITO/Sol-Gel/TiO <sub>2</sub> /SEO100/Au	5	30	184

## 3. Conclusions

We conclude that SL and CL layer plays important role in the EO performance during the poling to achieve higher EO coefficient. Better distribution of the electric field across the EO polymer is caused by the higher conductivity of sol-gel CL. The sol-gel is also important to protect a thinner thickness of EO polymer for the higher poling voltage and the early dielectric breakdown.

## References

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