# Silicon-Organic-Hybrid Independent Simultaneous Dual-Polarization Modulator: Device Theory and Design

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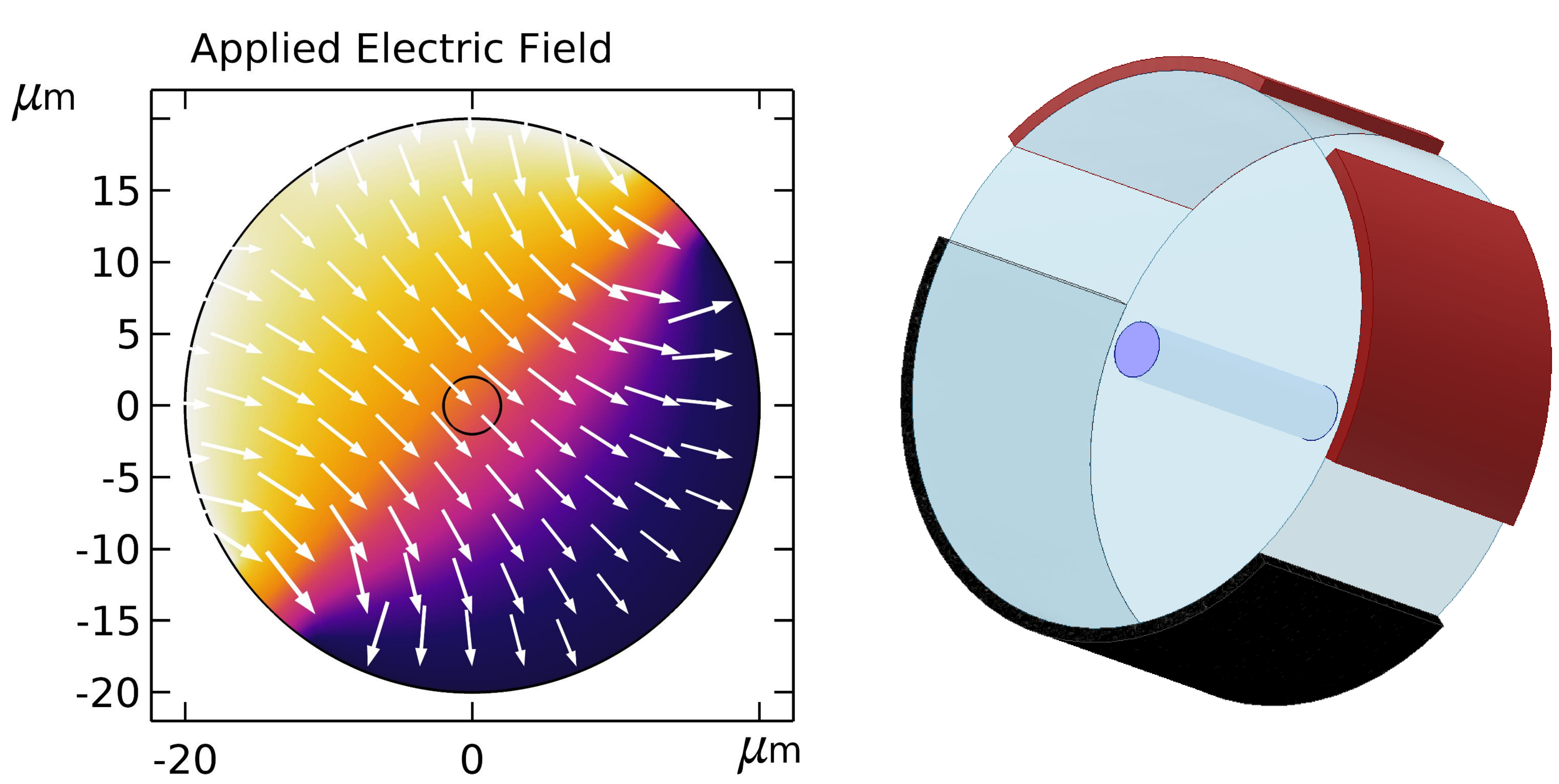
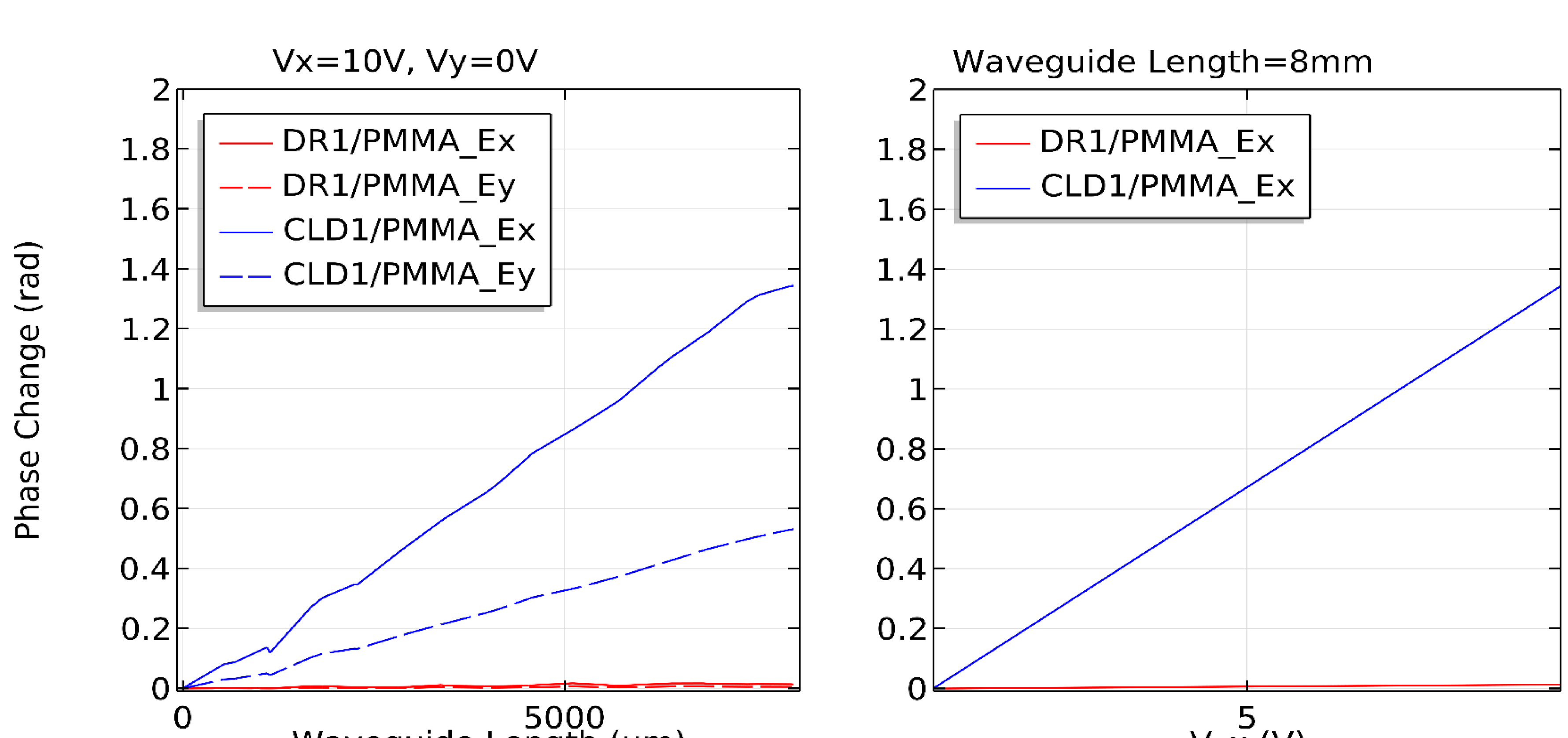
The implementation of photonics in telecommunication architecture has significantly increased the bandwidth of current data communications. An important component, the modulator, also occupies the largest area on a nanophotonic chip. Using electro-optic polymers (EOP), it is possible to modulate the phases of two orthogonal polarization-division multiplexed signals simultaneously yet independently, thus enabling a dual polarization modulator.




(a) (b)

**Figure 1**. Configuration of the dual polarization modulator
(a) Applied electric field distribution with both electrodes on
(b) Device geometry with 1 ground and 2 signal electrodes

Opposing electrodes placed along the X- and Y- axes apply orthogonal electric fields $\vec{E}_d$, whereas the EOP is thermally poled along the Z-axis of propagation.

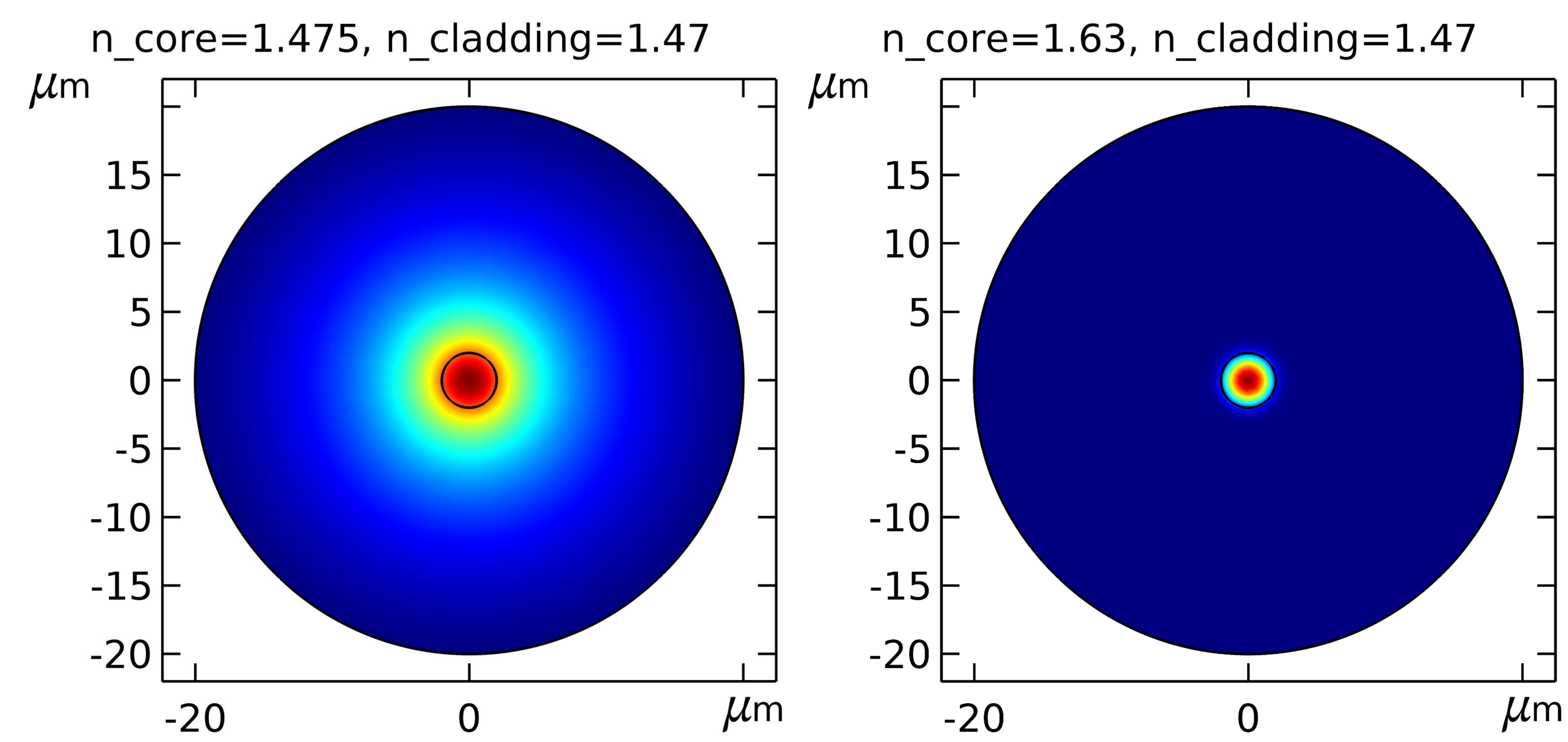



(a) (b)

**Figure 2**. Induced phase shift as a function of (a) waveguide length and (b) applied voltage along X-axis

| Parameter | | DR1/PMMA | CLD1/PMMA |
|---|---|---|---|
| Core Refractive Index, | $n_{co}$ | 1.63 | 1.475 |
| On-Axis Pockels Coefficient | $r_{33}$ | 85 pm/V | 7.6 pm/V |
| Off-Axis Pockels Coefficient | $r_{51}$ | 32.7 pm/V | 2.9 pm/V |

**Table 1**. Primary Variables for EOPM Design




(a) (b)

**Figure 3**. Optical confinement for core refractive index of (a) 1.47 (corresponding to DR1), and (b) 1.475 (CLD1) with glass cladding (index of 1.44)

Linearly polarized light propagating down the waveguide can be subjected to phase modulation by an $\vec{E}_d$ parallel to the direction of polarization (on-axis) using the Pockels effect,

$$\Delta n_d = \frac{1}{2} n_{core}^3 r_{jk} E_d$$

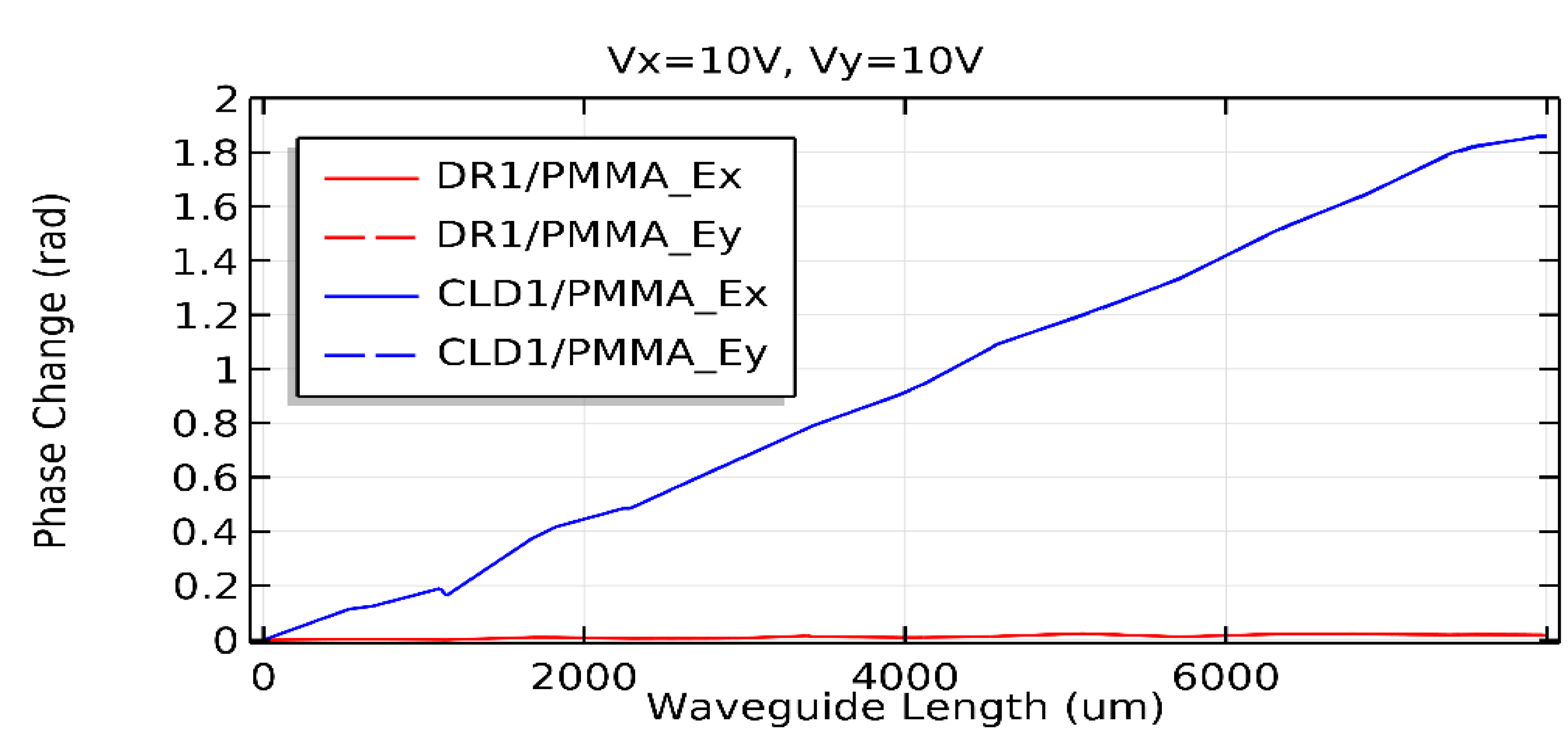



**Figure 4**. Phase change as a function of waveguide length based on the method of dual axis modulation

Our use of the COMSOL Multiphysics® Wave Optics module enables the characterization of a dual polarization modulator. This is a novel utilization of the linear electro-optic effect using both on- and off-axis Pockels coefficients.

1. L. Chrostowski and M. Hochberg, Silicon Photonics Design. Cambridge, England: Cambridge University Press, 2015
2. Günter, Peter, ed. Nonlinear optical effects and materials. Vol. 72. Springer, 2012.