Analysis of Strain-induced Pockels effect in Silicon

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Introduction: The discovered Pockels effect in strained silicon has made silicon a promising candidate material for realizing optical modulators and switches [1].

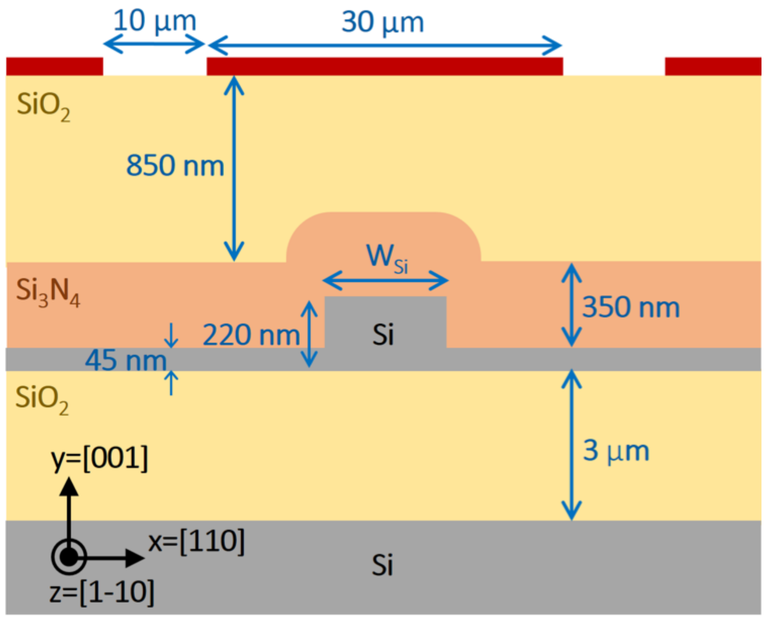

Fig. 1. MZI cross section designed for Pockels effect analysis [1].

Theory: We assume that $\chi^{(2)}$ is local function of ε and develop in Taylor series

$$\chi_{ijk}^{(2)} = \left.\frac{\partial \chi_{ijk}^{(2)}}{\partial \zeta_{\alpha\beta\gamma}}\right|_{\varepsilon=0} \zeta_{\alpha\beta\gamma}$$

where $\zeta_{\alpha\beta\gamma} = \partial\varepsilon_{\alpha\beta}/\partial x_\gamma$ is the strain gradient tensor.
The final expression for the effective dielectric susceptibility is given by

$$\chi_y^{eff}(\omega) = c_i o_i(\omega)$$

where $o_i(\omega)$ are combination of the weighted strain gradients.

USE of COMSOL Multiphysics: The strain profiles are computed taking into account the orthotropic model in ref [3] and the waveguide show a single mode behaviour.

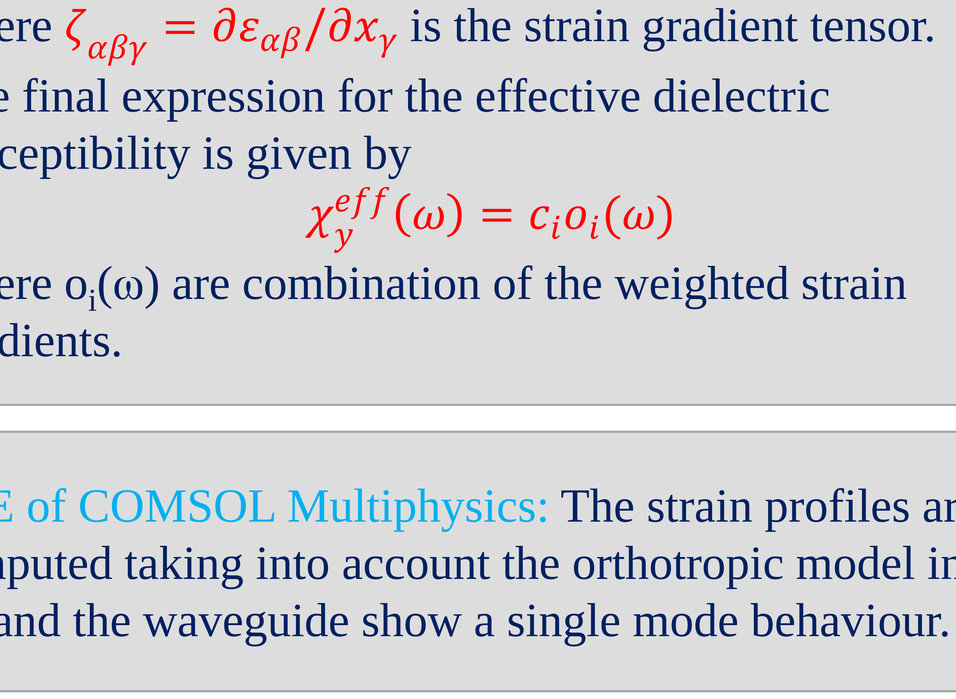

Fig. 2. Strain profiles for the cross section of ref [1] computed by taking into account ref. [3]

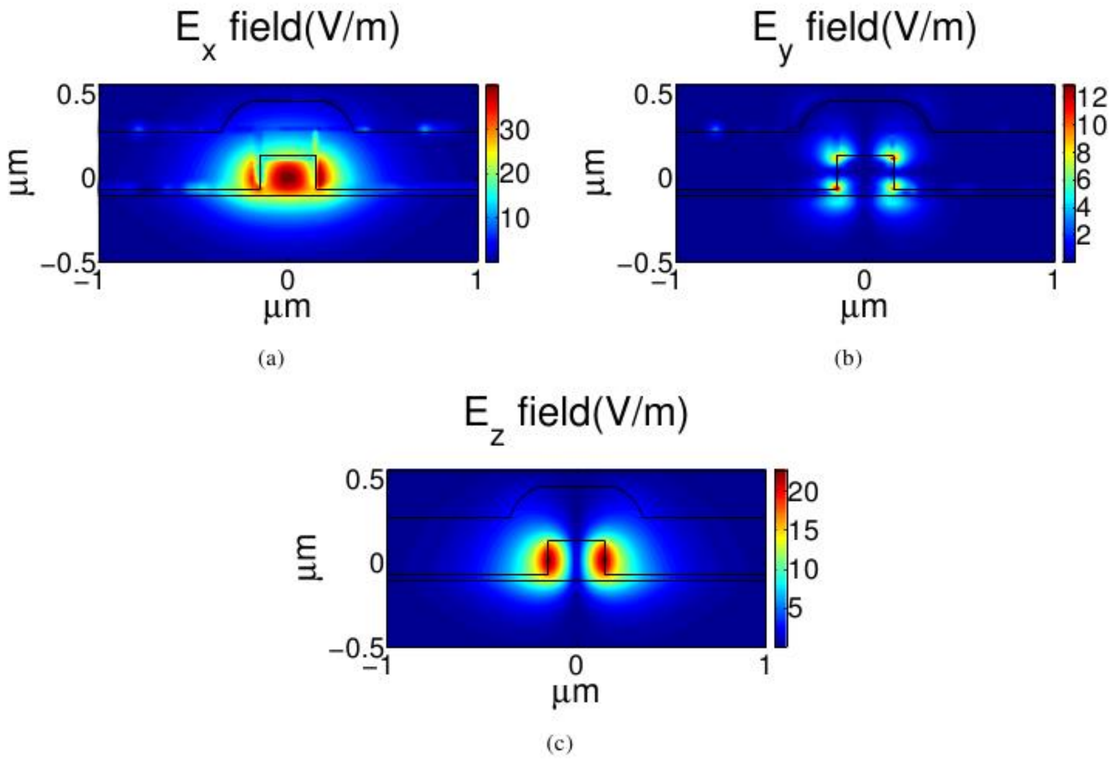

Fig. 3. The mode analysis for the waveguide cross section in ref. [1]

Results and conclusions: From the combination of the mode analysis and the mechanical deformation we obtained the values of the overlap integrals. Future experimental data will give the possibility of evaluating the c_i coefficients

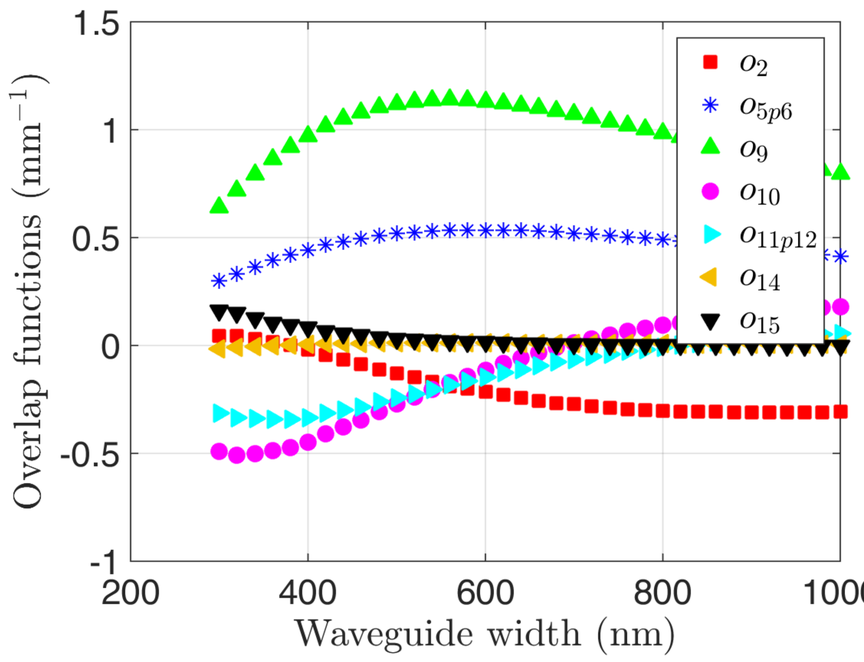

Fig. 4. Overlap integrals for the waveguide cross section as function of the waveguide width ref. [1]

References:

1. B. Chmielak, et al., "Investigation of local strain distribution and linear electro-optic effect in strained silicon waveguides," *Opt. Express*, **21**, (2013).
2. B. Chmielak et al., "Pockels effect based fully integrated, strained silicon electro-optic modulator," *Opt. Express*, **19,** (2011)
3. M. A. Hopcroft et al. "What is the Young's modulus of silicon?," *IEEE Journal of Microelectromechanical Systems*, **19**, (2010).