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Recent advances in strained silicon photonics

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Silicon photonics is being considered as the future photonic platform, mainly for the reduction of photonic system costs and the increase of the number of functionalities on the same integrated chip by combining photonics and electronics. However, silicon is a centrosymmetric crystal, which inhibits Pockels effect: a second order nonlinear effect which allows for light modulation at speeds that are not limited by carriers and driven at very low power consumption. Nevertheless, to overcome this problem, strain has been used as a way to deform the crystal and destroy the centrosymmetry which inhibits $\chi^{(2)}$. In fact, over the last few years Pockels electro-optic modulation [1–4] and SHG [5,6] have been claimed to be demonstrated in devices where the silicon active region is strained by a stress overlayer, usually made of SiN. Motivated by its enormous potential, the interest in strained silicon photonics devices has been growing in the past years. However, in most of the experimental works, carrier effects were not taken into account, which led to an over-estimation of the nonlinear coefficient [7].

In this work, we will present recent developments on strained silicon photonics taking into account parasitic effects including plasma dispersion effect and fixed charge effect under an electric field. We experimentally demonstrate Pockels effect in silicon waveguides strained by a SiN overlayer deposited by PECVD as a function of the wavelength and the waveguide width. Recent results on the development of nonlinear optics model under strain will be presented as well as high-speed measurements in order to well dissociate Pockels effect and plasma dispersion effect.

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References

[1] R. S. Jacobsen, K. N. Andersen, P. I. Borel, J. Fage- Pedersen, L. H. Frandsen, O. Hansen, M. Kristensen, A. V. Lavrinenko, G. Moulin, H. Ou, C. Peucheret, B. Zsigri, and A. Bjarklev, Nature 441, 199 (2006).
[2] B. Chmielak, M. Waldow, C. Matheisen, C. Ripperda, J. Bolten, T. Wahlbrink, M. Nagel, F. Merget, and H. Kurz, Optics express 19, 17212 (2011).
[3] D. Jones, *Title of publication*, Journal name, vol. 1, no. 2, pp. 121-127, 2012 B. Chmielak, C. Matheisen, C. Ripperda, J. Bolten, T. Wahlbrink, M. Waldow, and H. Kurz, Optics Express 21, 25324 (2013).
[4] M. W. Puckett, J. S. T. Smalley, M. Abashin, A. Grieco, and Y. Fainman, Optics letters 39, 1693 (2014).
[5] P. Damas, X. Le Roux, D. Le Bourdais, E. Cassan, D. Marris-Morini, N. Izard, T. Maroutian, P. Lecoeur, and L. Vivien, Optics Express 22, 22095 (2014).

[6] M. Cazzanelli, F. Bianco, E. Borga, G. Pucker, M. Ghulinyan, E. Degoli, E. Luppi, V. V´eniard, S. Os- sicini, D. Modotto, S. Wabnitz, R. Pierobon, and L. Pavesi, Nature materials 11, 148 (2012).
[7] C. Schriever, C. Bohley, J. Schilling, and R. B. Wehrspohn, Materials 5, 889 (2012).
[8] S. Sharif Azadeh, F. Merget, M. P. Nezhad, and J. Witzens, Optics Letters 40 (8), pp. 1877-1880 (2015)