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GLASS AND WAVEGUIDE POLING

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Abstract

Glass, e.g. silica glass, is one of the dominant materials in information technology because of its low fabrication cost compared to crystalline materials, and its superior optical properties such as high transparency and high optical damage threshold. However inversion symmetry of the glass matrix ensures the absence of optical effects based on second-order nonlinearity such as linear electrooptic effect and parametric frequency conversion. The ability to modulate a material's refractive index with an applied field, as in the electrooptic or piezoelectric effect, is necessary for making optical switches and electric field sensors. Frequency conversion of coherent radiation through parametric processes, such as second harmonic and sum or difference frequency generation, is also desirable to produce a large range of wavelength from fibre lasers and for construction of tunable laser sources. The development of a practical second-order nonlinearity in silica and related materials would add both modulators and frequency converters to the list of active fibre components. The advantages of integrability, e.g. monolithic integration of the above devices into optical fibres, and manufacturabilty would ensure widespread use of these capabilities.

Until fairly recently, second harmonic generation in specially treated glasses and glass fibres has been of more scientific than practical interest, owing to small levels of nonlinearity (several orders of magnitude less than in lithium niobate) that could be induced. A recent breakthrough is the observation of high second-order nonlinearities of the order of 1 pm/V in glasses and 0.2 pm/V in optical fibres using a variety of different techniques similar to those which are used for making polymer electrets: thermal poling, corona poling and electron implantation. These values of nonlinearity are large enough to be useful for parametric frequency conversion. The nonlinear coefficients, especially for the electrooptic effect, are still small, and so require long interaction lengths. This is not a significant problem in fibre applications where the issues are cost, integrability and packaging, not length. It is worth also noting one more important advantage of poled glass in comparison with nonlinear crystals, namely that the bandwidth of phase-matched second harmonic conversion in poled silica (0.78 nm·cm) is an one order of magnitude larger than in an equal length of periodically poled lithium niobate (0.06 nm·cm). Moreover the group velocity mismatches are about 130 fs/mm and 1.8 ps/mm respectively. This may be of great importance in short pulse work where large acceptance bandwidths and long interaction lengths are required.

A better understanding of the physical mechanisms of glass poling may lead to even higher values of nonlinearity, perhaps competitive with the best nonlinear crystals. In the talk we review recent progress in glass and waveguide poling.