CHARACTERISATION OF PERIODICALLY POLED MATERIALS USING MULTI-PHOTON MICROSCOPY

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Periodically poled crystalline materials are extremely attractive for processes such as second harmonic generation and optical parametric generation due to their very high conversion efficiency. For optimal performance, fabrication of poled regions with sub-micron tolerance is required. To date, measurement of successful fabrication has been performed using traditional brightfield microscopy, confocal laser scanning microscopy (CLSM) or second harmonic generation laser scanning microscopy (SHG LSM). Whilst brightfield microscopy is only capable of providing structural information from near the surface of the device, CLSM and SHG LSM can provide structural information at depths of up to several tens of µm inside the periodically poled crystal. However, periodically poled crystals used most frequently in practical nonlinear optical frequency conversion have a thickness >100µm, therefore CLSM cannot be used for their analysis. The effectiveness of the SHG LSM technique is also limited as the crystal orientation typically does not permit phase-matching, resulting in very low SHG signal intensities. This leads to either poor image quality or complex and expensive instrumentation to detect the signal to create an image. A novel imaging approach is therefore sought in order to inspect the crystal structure in its entirety.

We present multi-photon laser scanning luminescence microscopy (MP LSM) as an alternative minimally-invasive measurement technique which provides additional information about internal device structure with high spatial resolution. The high signal intensity produced by multi-photon excitation allows improved depth imaging and high contrast imaging at depths of several hundred µm is possible. By using MP LSM to build three-dimensional reconstructions of luminescent structures, as shown in Figure 1, we present a novel method of domain characterisation and damage analysis for periodically poled materials. We will discuss the application of this method for magnesium-oxide doped periodically poled lithium niobate (MgO:ppLN) characterisation but this flexible approach can also be employed to study other periodically poled media.

Figure 1: Comparison of 3D reconstructions of periodically poled MgO:LiNbO₃ obtained using a) confocal and b) multi-photon laser scanning luminescence microscopy.