飞秒激光与铁电晶体和金属相互作用和微加工

Interaction with and Micromachining in Ferroelectric Crystals and Metals by Femtosecond Laser

飞秒激光具有极窄的脉宽和超高的峰值功率，使得它在微加工方面有着其他传统激光脉冲无法比拟的优势。目前，我们在飞秒激光与物质相互作用领域研究成果包括:

1. 实验获得单、多脉冲作用下飞秒激光对铌酸锂及掺镁铌酸锂烧蚀阈值，结合铌酸锂晶体的本征缺陷和色心理论，合理解释了掺杂对其的影响;
2. 建立理论模型，提出飞秒激光在铌酸锂晶体表面诱导（亚）微米量级周期畴反转结构的可能性，并通过实验验证了理论预测。
3. 实验探究了飞秒激光金属烧蚀规律及钻孔加工工艺。并建立二维双温模型对飞秒激光与金属相互作用过程进行描述，理论预测及实验结果达到很好的吻合。

In contrast with traditional laser, Femtosecond laser has some incomparable advantages in microfabrication due to its ultra-short duration and extremely high peak power. In the past, several achievements are obtained in our group.

1. Single-pulse and multi-pulse ablated threshold fluence was gained for congruent and Mg-doped lithium niobate. The influence of doping was demonstrated and explained via color centre theory and intrinsic defect models of pure lithium niobate crystal;

2. Theoretic model was set up to predict that (sub-) micron-period domain reversal structures might be induced by fs pulses in LN, which was then verified by experiment;

3. Experimental study on ablation rules and hole drilling technologies of metals were conducted. 2D two-temperature model was established to describe the interaction process, which showed a good match with experimental results.

Surface Ablation of LN and Mg:LN

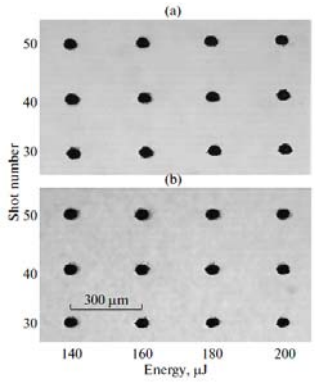


Fig. 4. The micrograph of ablation spot matrixes of the surfaces of (a) LN and (b) 6 mol % Mg-doped LN under multi shots (energy increases from left to right and shot number decreases from top to bottom).

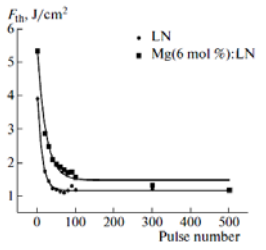
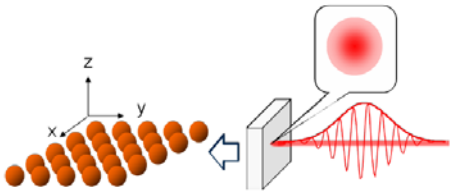


Fig. 6. Fit of threshold fluence as a function of the number of pluses by Eq. (4) for both LN and Mg:LN at λ = 800 nm and τ = 80 fs.

Domain Inversion Induced by Femtosecond Laser

Schematic of theoretic model：



The crystal was simplified as an n×n oscillator array in which the oscillators, representing the lithium ions of lithium niobate, are harmonically coupled and damped. The spatial and temporal distributions of femtosecond pulses were considered in the model.

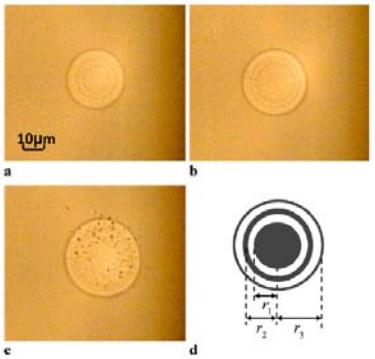
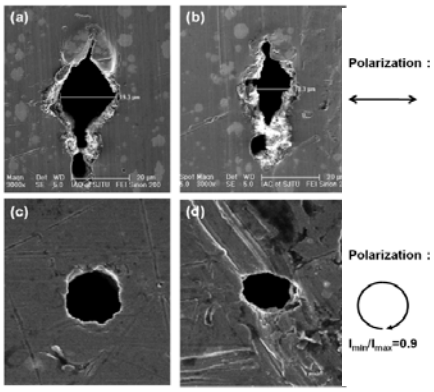
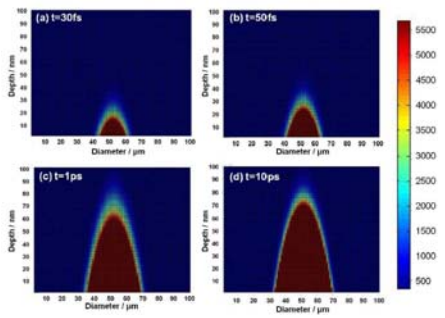


Fig. 2 Morphological features of the $X-Z$ plane surface of $LiNbO_3$ irradiated by a Z-direction polarized femtosecond laser pulse with the energy (a) 30 μJ, (b) 40 μJ and (c) 60 μJ after hydrofluoric acid etching and the schematic diagram (d)

Laser Ablation and Hole Drilling in Metals



SEM figures of exits of holes drilled by laser with different polarization.



Calculated by 2D two-temperature model, lattice temperature distribution of Al ablated by single femtosecond laser pulse.

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