# Bulk PPKTP by crystal growth from high temperature solution

Periodically-poled ferroelectric crystals are the nonlinear optical media of the future where the frequency conversion process can be tailored by a periodic structure of ferroelectric domains of alternating polarity, imprinted into the material. These crystals show unprecedented efficiency and other properties that were previously unattainable. However, the sample thicknesses obtained so far have limited their use to low and medium power applications only. We have addressed this problem with a novel growth method that yields larger crystals.

Until now the common method for obtaining a periodically-poled ferroelectric crystal was the electric-field poling technique. That is, local inversions of the spontaneous polarization are produced in a single-domain crystal using electric fields applied via patterned electrodes on the crystal surface. With this technique the grating periodicity can be controlled very well by lithographic patterning, but the high fields required limit the thickness obtainable to a few millimetres. Various growth techniques have been proposed in order to obtain larger samples with periodic domain structures, but unfortunately the obtained grating structures were not regular enough for use in practical nonlinear devices.

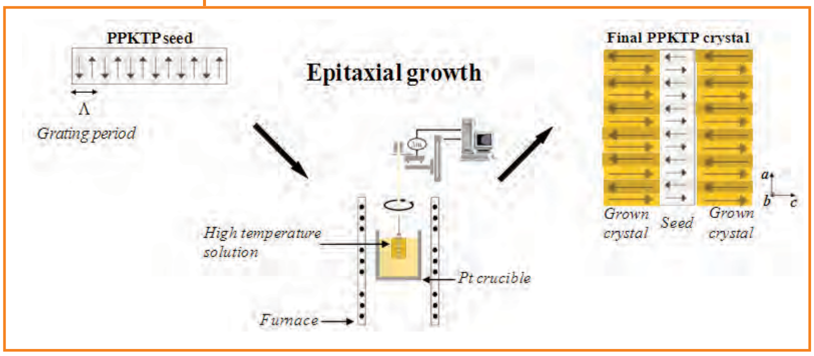
With the aim of increasing the size of periodically-domain-structured crystals having a controlled and regular grating period, we proposed an epitaxial growth process using thin seed plates that had been domain-engineered by electric field poling. We have demonstrated this process by growing PPKTP, that is periodically poled crystals of the orthorhombic *mm2* ferroelectric $KTiOPO_4$. The process is shown in Figure 1.

Epitaxial growth of PPKTP was performed onto the two *c* faces of PPKTP seed plates which had previously been inverted periodically with a grating period of Λ = 38.86 µm by application of electric fields.

We chose a flux composition that allowed crystal growth below the Curie temperature of KTP and below the roughening temperature of the c faces. Domain-structured KTP layers of up to 800 µm thickness were grown, by a procedure which could be scaled to much larger sizes. A sample is shown in Fig. 2(a). By scanning electron microscopy (SEM) on the *b* face, we could verify that the interfaces were of very high quality and that the domains had propagated through the full thickness of the sample without any measurable variation in size, see Fig. 2(b).

The high optical quality of the grown layer, in terms of regularity and extension of the domain grating, was verified by quasi-phase-matched second harmonic generation measurements using a laser beam propagating along the a axis and probing the $d_{33}$ nonlinear coefficient of the crystal.

Figure 1 : Flux growth process used to grow large, periodically poled KTP crystals starting from a periodically poled KTP seed.

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FURTHER READING

TEMPLATE-GROWTH OF PERIODICALLY DOMAIN-STRUCTURED $KTiOPO_4$
A. Peña, B. Ménaert, B. Boulanger, F. Laurell, C. Canalias, V. Pasiskevicius, P. Segonds, C. Félix, J. Debray, S. Pairis, Optical Materials Express 1, Invited paper, 185 (2011).

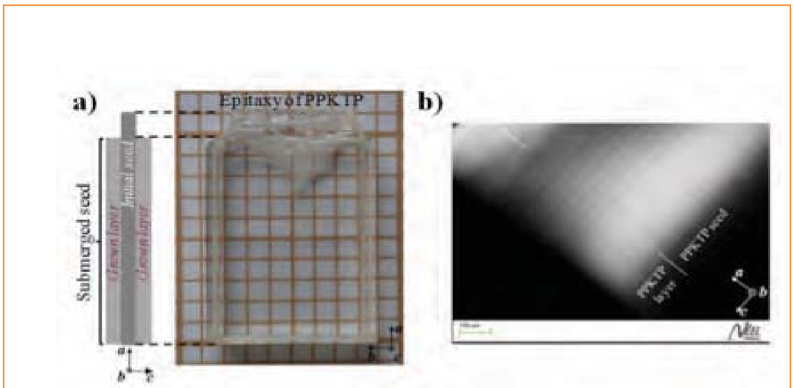


Figure 2 : Periodically domain-structured-KTP films grown on a PPKTP seed in a 0.1 KTP – 0.6 $KPO_3$ – 0.3 KF flux. a) Photograph of a PPKTP crystal and, at left, a cross-section showing the growth seed and its crystallographic axes. b) Scanning Electron Microscope image of the PPKTP seed and the grown layer.