INVESTIGATIONS OF PYROELECTRIC CRYSTALS FOR VACUUM ELECTRON SOURCE AND X-RAY APPLICATIONS

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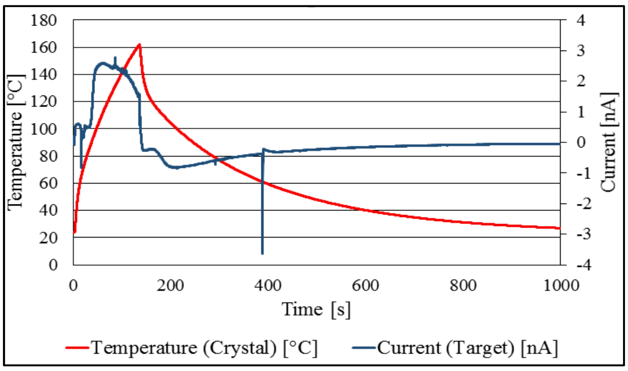
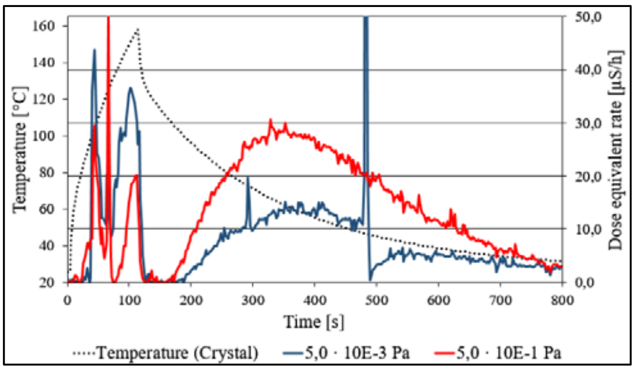
Subject of this report are fundamental experimental investigations of pyroelectric Lithium Tantalate ($LiTaO_3$) crystals showing comparatively high pyroelectric coefficients [1]. Changing the temperature of pyroelectric crystals in a low pressure atmosphere allows varying its polarisation. This causes the generation of a strong electrical field, which can be used to accelerate emitted electrons [2]. Accelerated electrons can be utilized in various applications, e.g. for the generation of X-rays [3].

An experimental ultrahigh vacuum (UHV) setup was developed for the investigation of those crystals. This paper examines the influences of different parameters on the characteristics and intensity of electron emission using pyroelectric crystals. Intensity has been determined by measurements of current in a target positioned facing the Z^- - surface of the crystal. Results are shown in Fig. 1 a). The main focus of the investigations is the optimization of vacuum conditions for electron emission and acceleration. It has been shown that a lower pressure of about $5 \cdot 10^{-3}$ Pa results in a low intensity and inconstant emission of electrons while a higher pressure of about $5 \cdot 10^{-1}$ Pa enables continual emission of electrons with high intensities, as shown in Fig. 1 b). Formation of accelerated electrons with high energies has been proven by generation of X-rays and measurements of the resulting dose equivalent rate.



a)



b)

Figure 1. Selected experimental results for a pyroelectric crystal $LiTaO_3$ with the geometry of 5 x 5 x 6 mm³ (X·Y·Z):
a) Crystal temperature and current (in the Al-target) characteristics with heating and cooling phase for a duration of 1000 s.
b) Corresponding X-ray measurements (dose equivalent rate) for different vacuum pressures $5 \cdot 10^{-3}$ Pa and $5 \cdot 10^{-1}$ Pa.

Vacuum pressure-dependent gas discharges with voltage breakdowns were observed. The measurements show that the vacuum pressure has a significant influence on electron emission and acceleration which is different to applications at atmospheric pressure [4, 5]. Improved measurement methods, analyses and novel approaches for X-ray applications will be presented and discussed.

References
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