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Surface Temperature Measurement for Improving Space Charge Distribution Measurements with Thermal Methods

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I. Introduction

There are various techniques for measuring space charge distribution by a thermal method [1]. They all begins by heating the sample surface by a laser or a heater for instance [2]. Then heat diffuses progressively in the sample which generates in turn an electrical signal correlated with the charge distribution. Figure 1a shows a conventional setup where the heating is produced by a laser pulse.

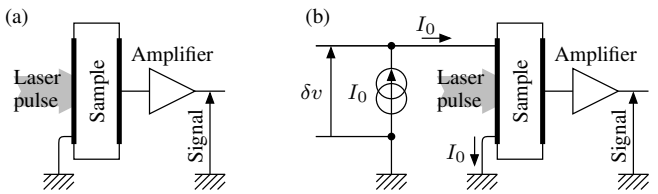

Fig. 1: (a) General setup for thermal methods. (b) Setup with surface temperature measurement.

If the generated signal is correlated with the charge distribution, it is also correlated with the heating function. The heating function is thus of great importance because any errors in its shape would reduce the accuracy of the charge distribution calculated. It begins to be critical for high spatial resolution measurements since the time on which the heating function evolves is no longer negligible compared to the one of the signal. It becomes then necessary to measure the sample surface temperature for knowing the heating function as accurately as possible and for opening the way to improve space charge distribution estimations with thermal methods.

II. Setup description

The setup presented in Figure 1b is used to measure the surface temperature by bolometric effect. The heated electrode is connected to ground at one of its side. A current I_0 is injected from its other side. Simultaneously the voltage δv is measured between each side of the heated electrode. Voltage δv is then proportional to the electrode resistance R and, because resistivity varies with temperature, it is an image of the surface temperature ΔT_0 of the sample. At the same time, thermoelectric effect also generates a signal proportional to ΔT_0.

III. Experimental results

The setup of Figure 1b has been implemented with a 5-ns-duration 1.4-mJ/mm^2-energy Nd:YAG laser pulse and a 600-μm-thick silicon sample covered by 100-nm-thick copper electrodes. A typical signal is shown in Figure 2a. The temperature rapidly rises, within 10 ns, and decreases less rapidly, within 235 ns, as heat diffuses trough the sample. By varying I_0, it is possible to isolate bolometric and thermoelectric effects as presented in Figure 2b in arbitrary units. It can be noticed that both effects give almost the same temperature evolution. One has

$$\delta v = \frac{\partial R}{\partial T} \times I_0 \times \Delta T + \frac{\partial v}{\partial T} \times \Delta T \qquad (1)$$

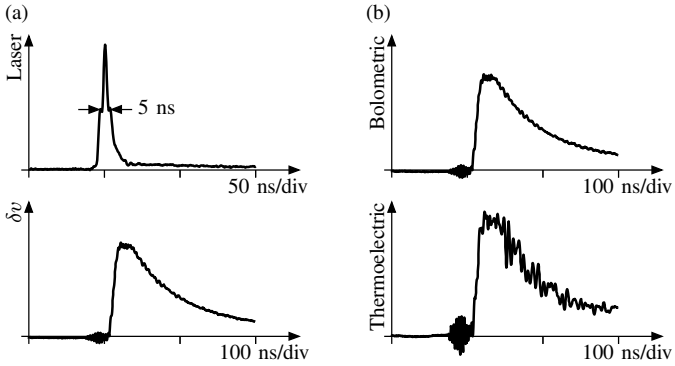

Fig. 2: (a) Laser pulse and typical measured signal for $I_0 = 50$ mA. (b) Surface temperature obtained by bolometric and thermoelectric effects.

IV. Conclusion

A setup for surface temperature measurement is proposed. Both bolometric and thermoelectric effects are used and give similar results: a signal proportional to the surface temperature. That opens the way for better estimations of space charge distribution with thermal methods especially for obtaining high spatial resolution.

References

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