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# THE ANALYSIS OF PHOTOTRANSFERRED THERMOLUMINESCENCE

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**Introduction:** The tutorial definition of phototransferred thermoluminescence (PTTL) is that this thermoluminescence is produced due to transfer of electrons by light from a stable deeper electron trap to a purposely emptied shallower one. If the deeper electron traps double up as both donors and acceptors and the process is no longer a one-way transfer one, and if the number of donors is unknown, how does one dispense with the academic notion and analyse the resulting systems of acceptor and donors?

**Material and method:** This discussion will draw from measurements on quartz, $Al_2O_3$:C, $Al_2O_3$:C,Mg and $Al_2O_3$:Cr. Experiments were performed on a RISØ TL/OSL DA-20 Luminescence Reader. The luminescence was detected by an EMI 9235QB photomultiplier tube through a 7 mm Hoya U-340 filter (transmission band 250-390 nm). Samples were irradiated at room temperature using a 90Sr/90Y β source at a dose rate of 0.10 Gy $s^{-1}$. All measurements were carried out at 1 °C $s^{-1}$. To measure phototransferred thermoluminescence, an irradiated sample was first preheated to a specific temperature to remove a given glow peak. The sample was thereafter exposed to 470 nm blue light to induce transfer of charge from deeper to shallower electron traps. A complete glow curve was then measured after illumination and any PTTL monitored at this stage.

**Results**: In the specific example of $Al_2O_3$:Cr, a glow curve measured up to 650ºC after irradiation to 140 Gy has four prominent glow peaks near 165, 340, 460 and 580°C respectively and a number of other weaker intensity secondary peaks (Fig. 1). Step-annealing was used to determine the role of each corresponding electron trap as an acceptor or a donor in the PTTL. Preheating temperatures preceding each illumination for 100 s were incremented at 10ºC intervals from 100 to 600ºC. The intensity of any peaks present after the sequential preheating and illumination were monitored. The most prominent PTTL appears at peaks I-III. Electrons traps corresponding to peaks I and II serve as dominant donors in the process with only minor contributions from all other electron traps including deep electrons traps. No PTTL is observed following preheating to 650ºC. The PTTL time-response profiles corresponding to various preheating temperatures display a range of patterns. Whereas the intensity of peak I is archetypal, going through a maximum with duration of illumination, that of the higher temperature peaks, whose donor electron traps lie between 500 and 600ºC, increase to saturation. For illustration, various other examples will be shown from quartz, $Al_2O_3$:C, and $Al_2O_3$:C,Mg The change of intensity with illumination time is modelled using coupled linear differential equations on the basis of systems of acceptor and donors whose number depends on the preheating temperature. For $Al_2O_3$:Cr, the systems of acceptor and donors are unconventional in that its elements, namely, the number of donors corresponding to an acceptor is indeterminate. The systems are studied using matrix-based methods where, for a general system of one acceptor with electron concentration $N_k$, and $n$ donor electron traps, the transport of charge at the acceptor and at $n$ donor electron traps each with electron concentration $N_j$ where $j = 1 \dots n$, can be expressed as

$$N' = AN$$

where $A$ is a matrix of elements corresponding to the eigenvector $N$. Using complementary vector-fields and empirical models, we will also describe competition effects, where supposed donor electron traps act in competition with acceptor electron traps.

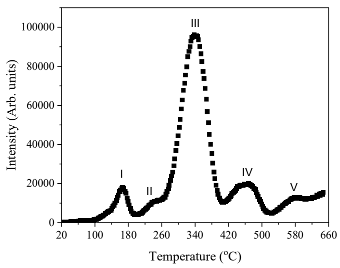


**Figure 1**. Glow curve of Al2O3:Cr with the most prominent peaks identified.