The role of different luminescence centers on the dose response of Al$_2$O$_3$:C OSLDs: a systematic investigation using continuous wave and pulsed OSL readouts

The optically stimulated luminescence (OSL) from Al$_2$O$_3$:C dosimeters (OSLDs) was characterized using continuous wave (CW-OSL) and pulsed (POSL) stimulations and different detection windows. The OSLDs were irradiated using a Co-60 source in a range of doses from 0.1 to 200 Gy. The readouts were performed using a custom made OSL readout system (530 nm LEDs stimulation). The stimulation light was filtered from the OSL emission with two different filter sets in front of the PMT: Hoya U340 and Kopp 5113. CW-OSL readouts were performed with both filters sets, while POSL readouts were performed solely with the U340 filters.

Al$_2$O$_3$:C has two primary recombination centers: one with a blue emission centered at around 420 nm (35 ms lifetime), and another with a UV emission centered at around 335 nm (<7 ns lifetime) [1]. The Kopp 5113 filters transmit in the blue region, whereas the U340 filters transmit in the UV. Because the UV emission in Al$_2$O$_3$:C is much weaker than the blue emission, the CW-OSL measured using the Kopp 5113 filters contains mostly the blue emission, while the CW-OSL measured using the U340 filters contains the UV emission and a contribution of the blue emission (tail of the blue emission band). The POSL readouts consisted of 2 ms pulses in 5 ms cycles, and the OSL was collected during the stimulation with counter A and in between stimulation pulses with counter B. Then, while the POSL stimulation was on, the net OSL signal had components from both recombination centers. However, while the POSL stimulation was off, the net OSL signal was comprised only of the slower blue emission. Because the blue emission has a lifetime much larger than the pulse duration, we assumed that its signal was constant during the detection time. Then, the difference between counters A and B yields the contribution of the faster UV emission to the net OSL signal.

Fig 1 shows the dose response curves for different filter sets and readout modes. The OSL signal in Fig 1 was defined as the integral over 10 s of stimulation. We have used different intervals of integration to define the OSL signal as well as the integral of the entire OSL decay curve. Three OSLDs were evaluated for each dose. The OSL signal was defined as the average OSL intensity with its standard deviation as the error. The solid lines in Fig 1 represent the linearity of the OSL signal as a function of dose. To quantify the deviation from linearity we defined the supralinearity index (Fig 2). Deviation from unity indicates a non-linear behaviour. We concluded that the UV emission has much higher supralinearity than the blue emission in the dose response of Al$_2$O$_3$:C OSLDs. A higher range of linearity can be achieved by selectively choosing detection of the blue emission, which can be performed using optical filters or POSL.

Impact: The results of this work may assist in the development of: i) new commercial OSL readers; and ii) dosimetry protocols on the use of OSLDs, such as the ongoing TG-191.