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Hydrogen diffusion observed in photoinduced YO_1H_2 thin films

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Materials showing high photoresponsive electrical resistance have attracted considerable attention due to their photoelectronic applications.[1] Recently, we have reported that yttrium oxyhydride (YO_xH_y) epitaxial thin films exhibit a repeatable photo-induced insulator-to-metal transition by UV laser illumination and thermal relaxation.[2] The photo-induced metallization likely originates from the carrier generation reaction: $H^- + h\nu \rightarrow H^+ + 2e^-$, which generates excess electrons and protons.[2,3] This suggests that a local environmental change around hydrogen in the epitaxial YO_xH_y thin film plays an important role in the photo-induced metallization process. To further understand the hydrogen dynamics in the YO_xH_y epitaxial thin film, here, we used ^{8}Li β-NMR for pristine and UV-illuminated thin films. For the as-fabricated sample, the spin-lattice relaxation rate ($1/T_1$) is constant as ~0.2 s^{-1} in the temperature range between 100 to 300 K. For the UV-illuminated sample, the temperature-independent 1/T1 of ~0.3 s^{-1} is also observed at temperatures below 200 K, indicating an increase in $1/T_1$ by UV illumination. There are two possible origins for the increase in $1/T_1$: one is the generation of color centers and the other is the enhancement of the interaction between dilute paramagnetic moments and photocarriers. Furthermore, we found that $1/T_1$ increases with increasing temperature only for the UV-illuminated sample at temperatures above 200 K; this implies a change in the nuclear magnetic field due to hydrogen dynamics. These results suggest that the hydrogen dynamics are thermally activated and a change of the local environment around hydrogen under UV illumination.

References:
[1] Li et al., Phys. Status Solidi B 249, 1861 (2012).
[2] Komatsu et al., Chem. Mater. 34, 3616 (2022).
[3] Hayashi et al., Nature 419, 462 (2002).

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