Relaxation Times Analysis in Superconducting Tungsten Rhenium-Based Films for Single Photon Detectors

Abhishek Kumar[1,2], F. Colangelo[1,2], F. Avitabile[1], C. Cirillo[2], C. Attanasio[1,2,3]

[1]*Dipartimento di Fisica "E.R. Caianiello", Universit`a degli Studi di Salerno, I-84084 Fisciano (SA), Italy*

[2]*CNR-SPIN, c/o Universit`a degli Studi di Salerno, I-84084 Fisciano (SA), Italy*

[3]*Centro NANO MATES, Universit`a degli Studi di Salerno, I-84084 Fisciano (SA), Italy*

Corresponding author email : abkumar@unisa.it

We analysed electron energy relaxation times (τ_s) in superconducting pure tungsten rhenium (WRe, T_c ~ 4.5 K) and nitrogen doped- WRe (WReN, T_c ~5.5 K) films, and evaluated total phase scattering rate (τ_φ), which is dependent on various characteristics scattering times: electron-electron ($\tau_{e\text{-}e}$), electron-phonon ($\tau_{e\text{-}ph}$) and electron-fluctuation ($\tau_{e\text{-}fl}$) [1-4]. Short τ_s facilitate the fast response, minimum jitter time, improved detection efficiency and a larger ratio of $\tau_{e\text{-}ph}/\tau_{e\text{-}e}$ favors to a larger hotspot size, which is beneficial for SSPDs and can be measured through magnetoconductivity (MC) measurements. The MC analysis was done by incorporating superconducting fluctuations [5, 6] and weak localizations [7] for the WRe and WReN films of the same thickness 5 nm only. The evaluated τ_φ as a function of temperature, $\tau_\varphi(T)$, is shown in Fig. 1 for WRe (red curve) and WReN (blue curve). The observed short $\tau_\varphi(T)$ values and the larger $\tau_{e\text{-}ph}/\tau_{e\text{-}e}$ ratio for WReN (~1.51) compared to WRe (~1.42), confirms its better suitability for SSPDs applications. Furthermore, the measured τ_φ values fall within the range reported for established SSPD materials such as WSi [1], NbN [2], NbTiN [3], and WGe [4], highlighting the potential of WRe-based films for next-generation single-photon detectors.

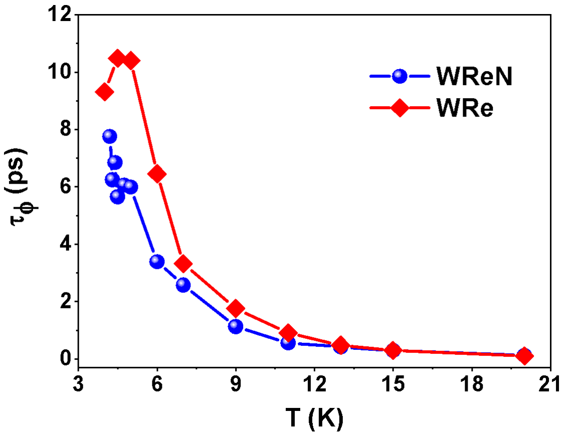

Fig. 1: *Phase scattering rate as a function of the temperature as measured from magnetoconductivity analysis for WRe and WReN films 5-nm thick.*

References

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