**INTRODUCTION**

**Motivation**

The development of high-repetition rate capabilities at LCLS II has unlocked the possibilities for new measurements to observe, in detail, the photoinduced dynamics in quantum materials such as superconductors. This understanding is important for:

- Fundamental and applied sciences to inform an approach towards room-temperature superconductivity.
- Furthering the development of quantum electronics.

**Pump–probe**

Pump–probe schematic showing the experimental setup and example of data acquisition. [1]

- Transient effects can be mapped by taking multiple measurements using short laser pulses and precisely changing the delay between pump/probe.

**High–repetition rate**

Advantages:

- More sensitive measurements with higher signal to noise ratio.
- Accelerated data taking throughput.

**Challenges:**

- Thermal heating effect (especially problematic for measuring superconducting effects at low temperatures).
- X-ray/laser penetration depth mismatch, when comparing on- and off-resonance responses.

**Approach**

To address these challenges:

- Use thin and transferrable membrane on high thermal conductivity substrate.
- Use simulations to quantify and validate the improvements in thermal dissipation using the new membrane method.
- Determine limitations and potential improvements.

**RESULTS**

**Thermal simulations**

Bulk and membrane YBCO on sapphire were simulated in COMSOL under pumped beam power.

**Simulation Parameters:**

- Material parameters such as $C_v(T)$ and $\kappa(T)$ taken from literature values. [4]
- Heat in–flow from 800 nm wavelength pump beam at 15 mW with 0.1 mm radius gaussian footprint.
- Heat out–flow from fixed temperature on copper face.
- Thermal contact boundary condition (BC) between membrane layers, thin layer BC between samples and cold finger.

**Experimental Data**

Normalized amplitude in optimally doped YBCO single crystal and membrane on Sapphire as a function of temperature. [2]

**Data Comparison**

Plot of simulation versus experimentally measured the heating effect. (Note: Experimental YBCO membrane data near zero)

**Vibration isolated cryostat**

Helped construct and take measurements of LCO, LBCO, V2O3 qRIXS early science samples with our cryostat.

**Example of initial data:** Fluence dependence of a 1 µm pump-probe response from bulk LBCO as 25K.

**ONGOING AND FUTURE WORK**

- High–repetition rate experiments of YBCO.
- Performing thermal simulations and analysis on V2O3.
- Complete data analysis of numerous measurements taken using the cryostat and 1 µm carbide laser.

**CONCLUSIONS**

- Successfully produced thermal simulations for bulk and membrane YBCO on sapphire samples.
- Simulations agree with experimental data.
- Simulations of YBCO membranes on high thermal conductivity substrates perform substantially better than bulk YBCO.
- Produced order–parameter simulation for zero–gap superconductors using TDGL theory.
- Vibration isolated cryostat was a great success achieving $< 5 \times 10^{-9}$ hPa pressure under cryo-cooling and no visible vibration transfer.
- Cryostat enabled the first testing of the qRIXS early science samples at 1µm and high repetition rates.

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**REFERENCES**