At the limits of temperature: new sensors for accurate measurement of thermal conductivity of molten salts

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The Issue

- Thermal conductivity (TC) measures **how easily heat flows through a material** and is critical for efficient heat management.
- In Concentrated Solar Power (CSP) plants, **molten eutectic salts are used as heat transfer fluids (HTFs)** to store solar energy for electricity production.
- **HTFs with high TC are desirable for maximum heat transfer efficiency.**
- Measuring the thermophysical properties of molten salts is challenging due to their **corrosiveness and high operation temperatures (200-700 ºC),** and **disparate data** is reported for these properties (Figure 1).
- Current CSP systems **mainly use nitrate salt mixtures that are stable up to 300-400 ºC**, limiting operation range
- **LiNaK (a eutectic mix of Li, Na, and K carbonates) have a working temperature up to 700 ºC**, but reported thermophysical data is also conflicting.

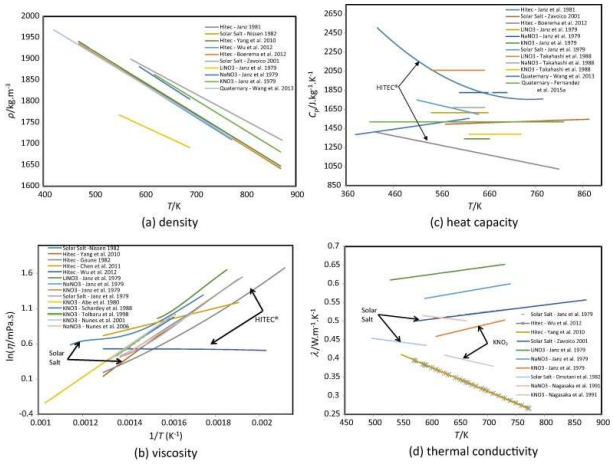


Figure 1 – Data disparity of the thermophysical properties of several eutectic salt melts used as HTF materials. Data taken from [x].

The main goal of this project is to develop platinum and nickel thin-film sensors on alumina substrates capable of operating in high-temperature and highly corrosive media, such as molten LiNaK, and to provide accurate thermophysical data to support the design and optimization of CSP plants using LiNaK as the heat-transfer fluid.

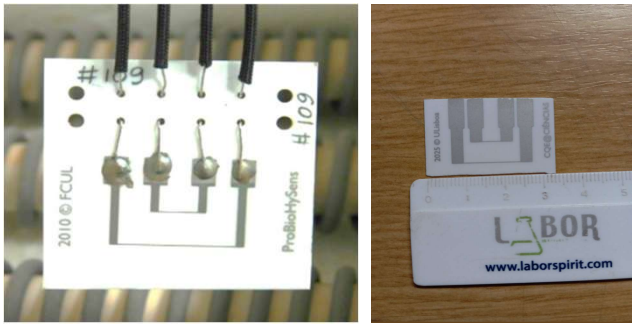


Figure 2 – Thin-film Pt sensor examples made in ESE.

In Our Lab

- The **Extreme Systems and Environments (ESE)** Lab is developing **platinum- and nickel-based thin-film sensors (Figure 2)** to measure the thermal conductivity (TC) of molten eutectic salts at high temperatures.
- The sensors use **transient-state measurements**, which take only a few seconds and reduce errors caused by heat convection in the fluid.
- **Platinum** is widely used for temperature sensing because of its **high chemical and physical stability and its linear resistance–temperature relationship** up to about 700 °C.
- Above ~700 °C, platinum thin films can **degrade due to hillock formation**, a major challenge for high-temperature applications[5].
- Previous studies suggest that an **alumina protective layer can reduce hillock formation** and protect the sensor in harsh molten salt environments.
- **Alumina-coated sensors** could enable TC measurements in molten LiNaK over a temperature range of 400–800 °C.
- Due to platinum's high cost and limited availability, the lab is also **developing nickel-based thin-film sensors** as a more economical alternative.

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