Conceptualization and realization of thin film thermocouples

Graduate

Kevin Meili

Introduction: Thermocouples are based on the thermo-electric phenomena called Seebeck-effect. A temperature gradient gives rise to higher electron energies resulting in an electric field. The contact between two dissimilar metals, with their respective Fermi-level and work function, reaches for energetic equillibrium. Using two junctions at different temperatures, will therefore generate a thermo-electric voltage which can be measured, as depicted on Figure 1. This effect is used to classify material properties in solid-state physics. Using a thin film thermocouple, properties such as the heat capacity and lattice constant can be derived for tiny samples. The goal is to classify material behaviour at pressures up to 10kbar at liquid nitrogen temperature (77.3K).

Definition of Task: This bachelor thesis has the goal to develop an apparatus for successful thin film thermocouple production. The process used is either thermal evaporation or sputtering, thus the apparatus has to be suitable for both. For precise adjustment, the stencil has to be adjustable by 0.1mm.
A mounting mechanism has to be developed to reliably secure differently formed substrates, with dimensions of 2mm. Furthermore, thermocouple material pairings are classified and deposition techniques are studied.

Result: Experiments have shown that the generated electromotive force (emf) from heat exposure is dependent on the film thickness. 80nm yields most stable and compliant results in regard to theoretical calculations. Sputtering has shown more consistant results than thermal evaporation. The apparatus guarantees reliable and efficient thermocouple production. A sufficient high vaccum is achieved quick which ensures good quality of the deposition film. The process developed is therefore suitable for probe preparation, regarding material classification in the high pressure cell.

Fig 1: Fermi energy significance resulting in a potential difference along a conductor exposed to temperature gradient.
S. Kasap, Principles of Electronic Materials and Devices

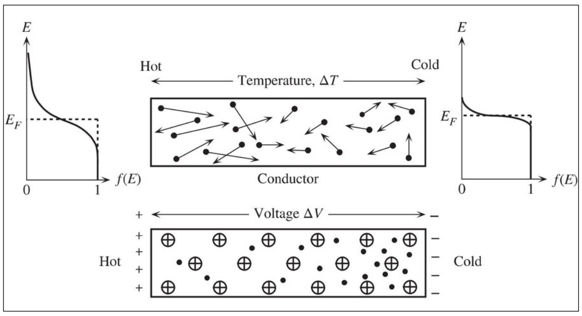


Fig 2: Drawing of the assembly, with the tiny adjustment screw. Diameter 32mm, height 10mm.
Own presentment

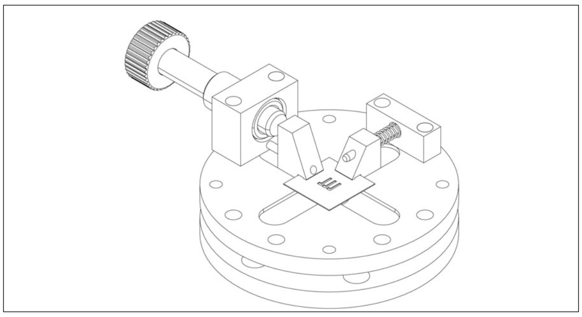
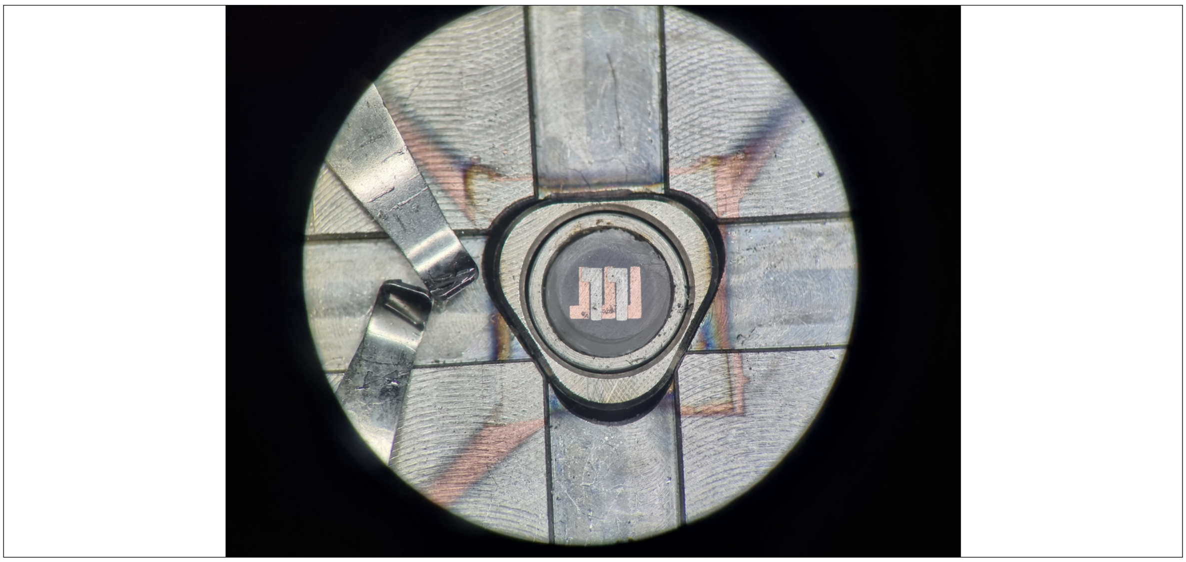


Fig 3: Microsopic picture of a type T thermocouple deposited on a POM substrate. Length 1.2mm, film thickness 80nm.
Own presentment



Advisor
Prof. Dr. Benno Bucher

Co-Examiner
Dr. Jürg Neuenschwander, EMPA, Wetzikon ZH, ZH

Subject Area
Sensorics, Construction and System Technology