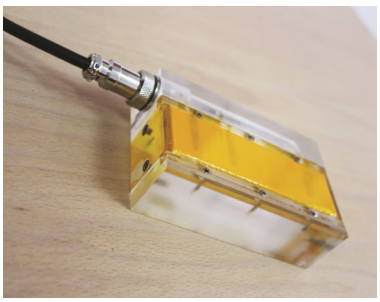
Thermal Conductivity of Solids

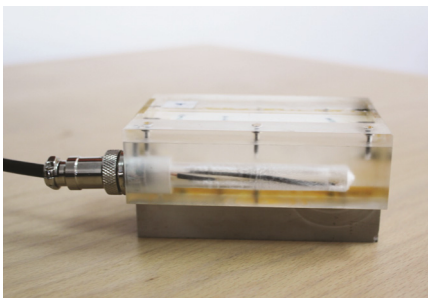
Transient Hot-Wire Technique

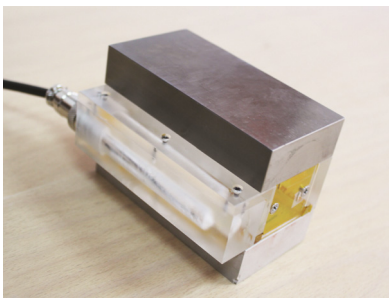
thw-01S The first portable instrument with 2% absolute uncertainty

Accu instruments

The main problem in the application of the Transient Hot-Wire technique to solids was always the contact resistances. The problem has been eliminated in our new sensor. The sensor is composed of two thin platinum wires (to avoid end effects) embedded in a soft silicone-paste layer, that rests on the one side on a plastic support. On its other side, the solid sample to be examined is placed. A thin polyimide film protects the silicone paste from the solid. Thus heat from the wire, is transmitted through the silicone paste to the solid on the one side and the plastic support on the other side. The thermal conductivity of the sample is obtained by modelling through FEM, the exact geometry of the sensor.







According to Fourier's Law for heat conduction, the thermal conductivity is the property of a material to conduct heat. **The material must be homogeneous.**

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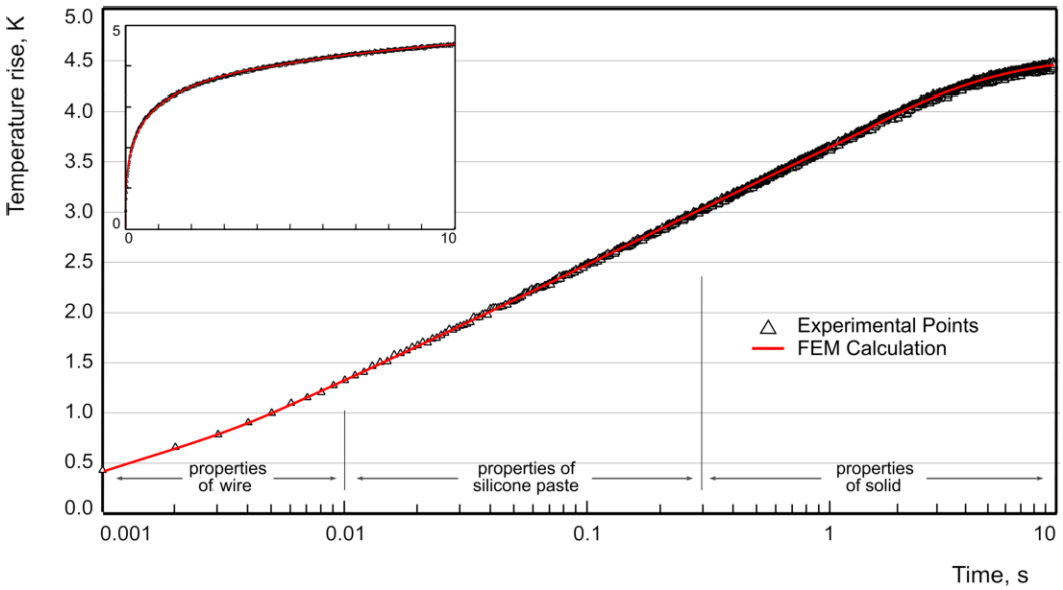
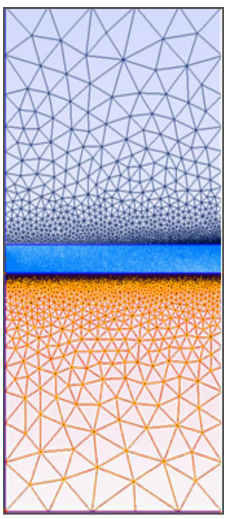
An automatic electronic bridge records 500 resistance rise points in time from 0.001 to 10 s. These are converted to temperature rise vs time. Assuming a value for the thermal conductivity of the sample, the full Fourier equations (in the wire, in the silicon paste and in the support and sample) are solved by FEM, and the resulting temperature rise vs time line is compared with the experimental one. When the two lines coincide, then the correct thermal conductivity value of the sample is found. The whole process of iteration is accomplished by a novel way employing Machine Learning and the method of Bayesian Optimization.





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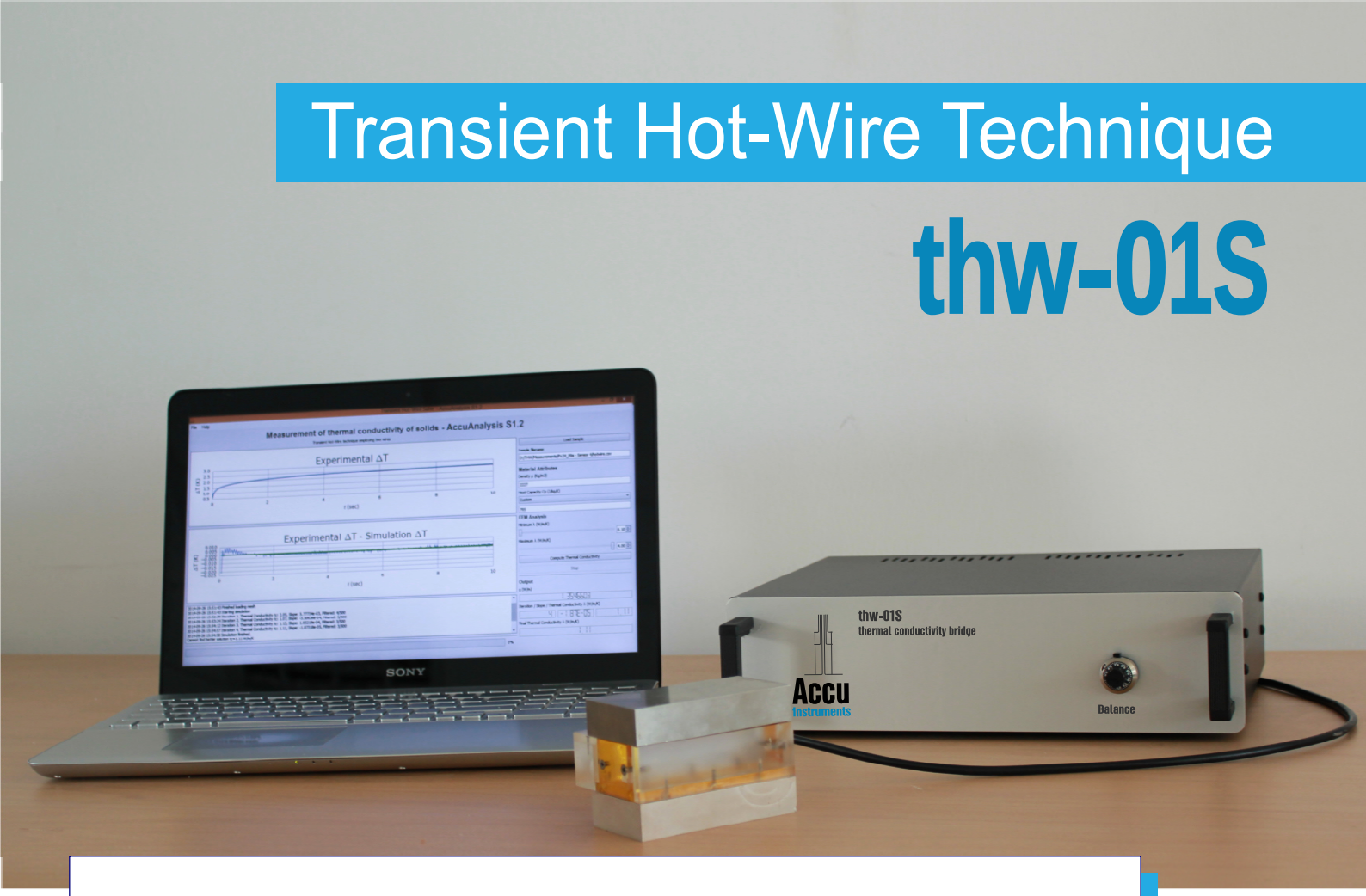
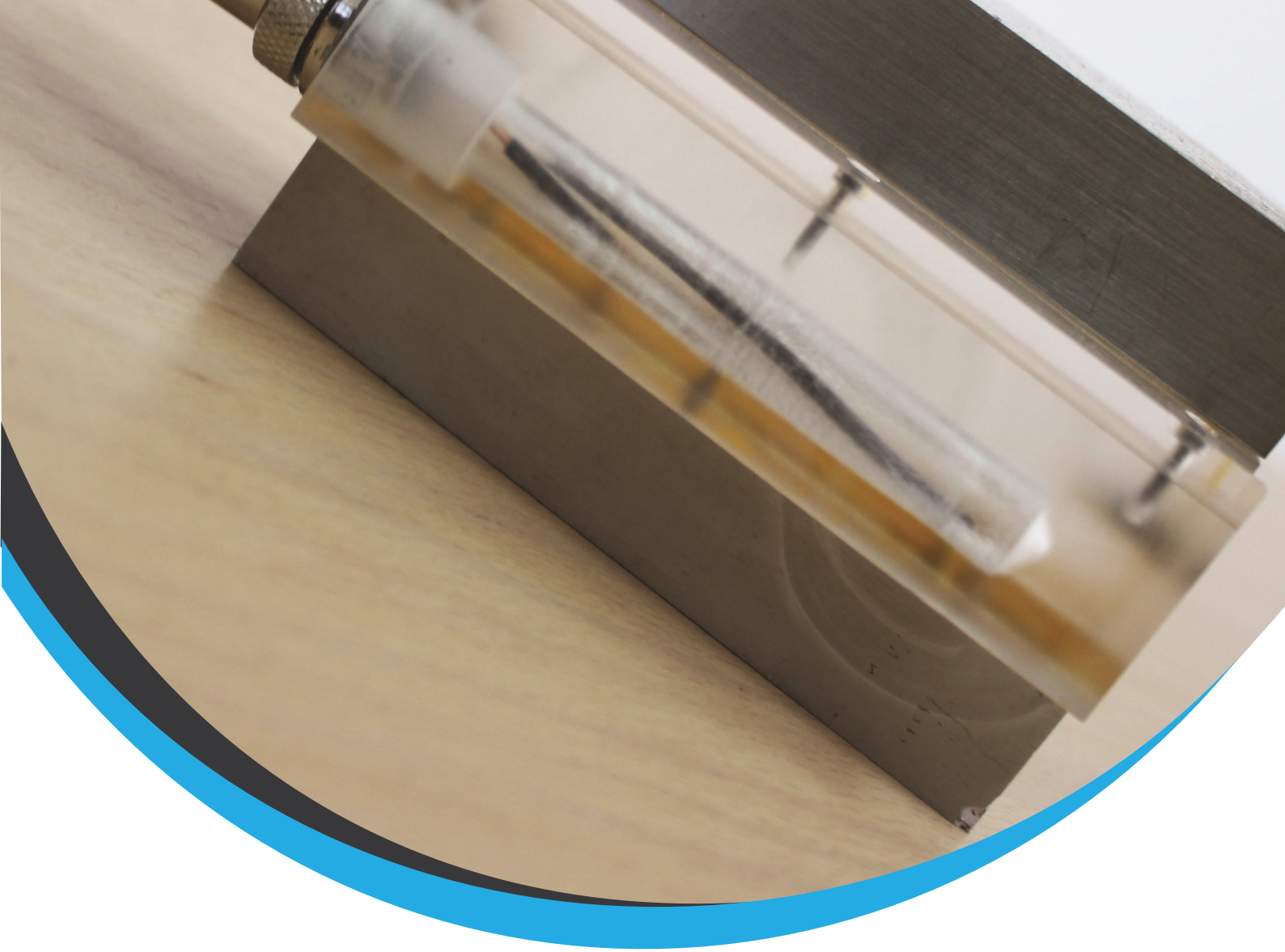


- Measurement of the thermal conductivity of solids (0.1 to 4 $Wm^{-1}K^{-1}$)
- Transient Hot-Wire technique (2-Pt wires) embedded in a silicon film
- Reliable results with low absolute uncertainty of 2%.
- Portable easy to use instrument.
- Full theoretical model. No approximations!
- Absolute technique, i.e. no calibration or reference sample is required.
- Suitable for users in industry, academia, and R & D institutions.

The successful Transient Hot-Wire technique is applied in the measurement of the thermal conductivity of solids, by employing a thin Pt wire (actually two wires, to correct for end effects). The thermal conductivity of the sample is determined by observing the temporal temperature rise of the embedded thin wire, when it is subjected to a step voltage. In this way, electrical current flows through the wire and heats it up, thus creating in the sample a line source of essentially uniform heat flux per unit length that depends on the thermal conductivity of the solid sample.

One of the main advantages of our technique, is that the whole procedure of measurement can be checked by measuring the thermal conductivity of toluene (known to 0.5%) prior to embedding the wires in the silicon layer.



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Design by Elena Papadopoulou (info@26adv.gr)