Temperature Sensing Options for Magnetic Nanoparticle Frequency Response Profiles in an RF Field

Different experiments require different types of sensors in order to measure and record the rate of change of temperature in magnetic nanoparticles exposed to an RF field.

In this article, we discuss the temperature sensor options available with the magneTherm system from Nanotherics. The most cost effective option would be a thermocouple for calorimetric experiments. However, thermocouples are prone to electromagnetic interference, so the signal to noise ratio will vary depending on the subjected alternating magnetic field.

Values recorded for initial and final temperature readings before and after exposure to alternating magnetic fields, along with an appropriate control/blank sample, can be used to calculate the rate of change over time and derive an accurate SAR value.

Figure 1. *Type T thermocouple and electronics (USB Connection Thermometer)*

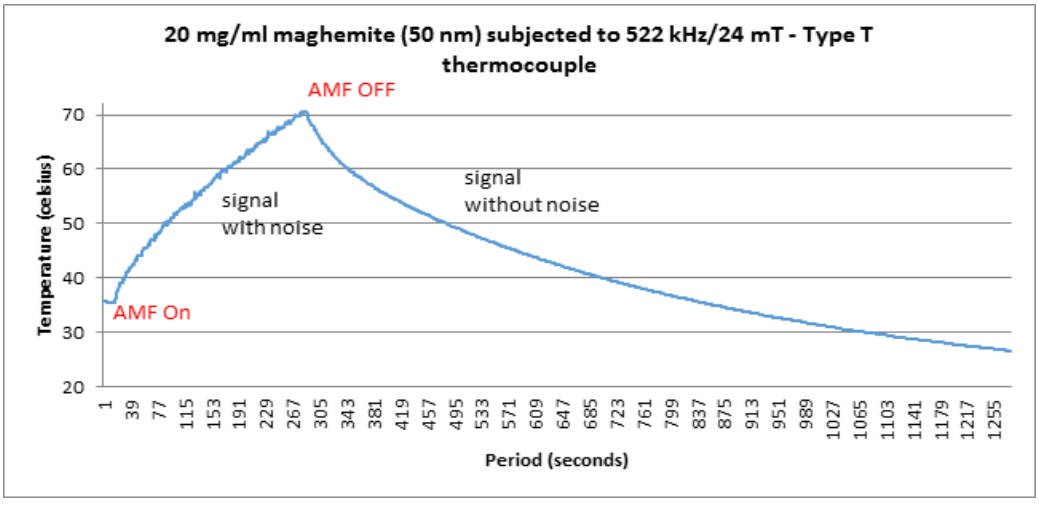

Figure 2. *Signal and noise with a thermocouple in a magneTherm system – 522 kHz used as noise shown is at a maximum at this frequency and reduces above or below this*

Fibre Optical Temperature Sensors

These difficulties can be eliminated by using a more appropriate sophisticated temperature sensing technology, widely known as fibre optical sensors. Temperature can be measured using a modified fibre which displays evanescent loss that varies with temperature, or by analysing the Raman scattering of the optical fibre.

As there is no voltage or metal involved here, these sensors are not prone to electric and magnetic interference. These more sensitive sensors are costly, but do provide accurate measurements, and are fully compatible with the magneTherm system.

Multichannel optical sensing platforms can also be deployed with magneTherm systemsto measure temperature at various points within the sample simultaneously. This option is far more suitable for calorimetric experiments in the magneTherm system.

Figure 3. *Single, Dual channel and multichannel optical temperature sensing technology compatible with magneTherm system*

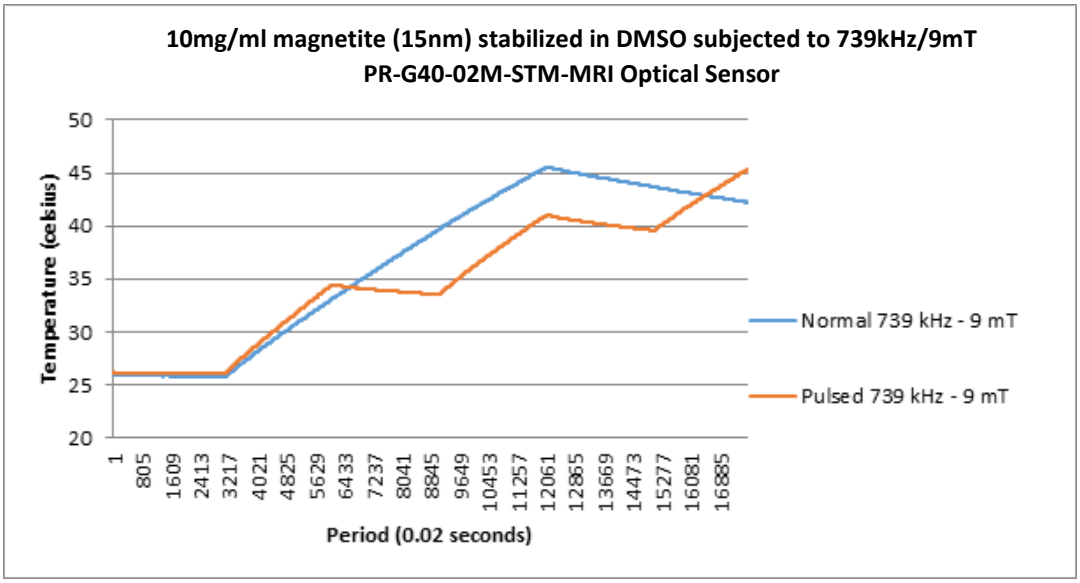

Figure 4. *High resolution accurate real time temperature change measurement using optical temperature sensor in a magneTherm system*

Temperature Sensing for In Vivo/In Vitro Experiments

When it comes to in vivo/in vitro experiments, a more suitable remote sensing/non-invasive option is required, primarily due to issues such as contamination of sterile bio-samples/bio-hazard perception.

Most of all, as Magnetic Fluid Hyperthermia technology is a proposed cancer therapy technique, a suitable sensing, recording and real time temperature monitoring technology is required in order to measure and monitor the temperature change within the cells, tissue and/or animal as a whole, with the above issues in mind.

The above requirements are fulfilled with the help of infrared thermography. The aggregate of radiation emitted by a body escalates with temperature, which allows one to see differences in temperature through an infrared thermogram. Thermal images are actual visual displays of the quantity of infrared energy emitted, transmitted, and reflected by a body.

Compatibility with magneTherm Technology

MagneTherm technology is compatible for use with an infra-red imaging module, which allows the user to record and measure real time temperature change for in vivo / in vitro experiments during exposure to high frequency alternating magnetic fields. Along with thermography, single spot and multiple spot temperature recording is also available, facilitating the collection of multiple data points simultaneously. The other significant advantage of these high quality thermograms derived with an infrared module is that they can be post-processed multiple times for additional data exemplification.

Fig 5

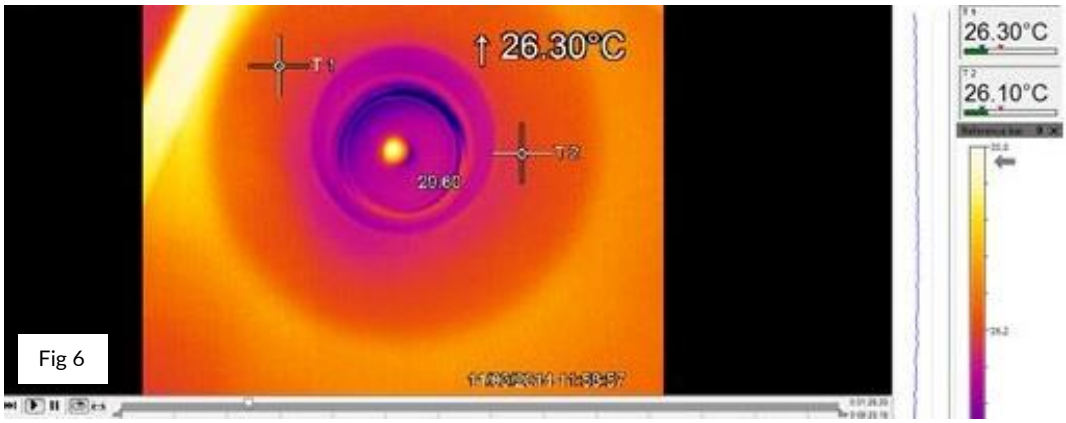

Figure 5 & 6. *Real time temperature change measurement using infrared thermography module attached to a magneTherm system*

The magneTherm system is tested to be compatible with all the aforementioned temperature sensing options. As the measurement is independent of the control system, customers can utilise existing laboratory temperature measurement systems, keeping costs affordable.

nanoTherics

For more information or to request a quotation please visit www.nanotherics.com.