APPLICATION NOTE

Lake Shore Model 74035 Single Stage Variable Temperature (SSVT) option for use with 7400 series VSM Systems

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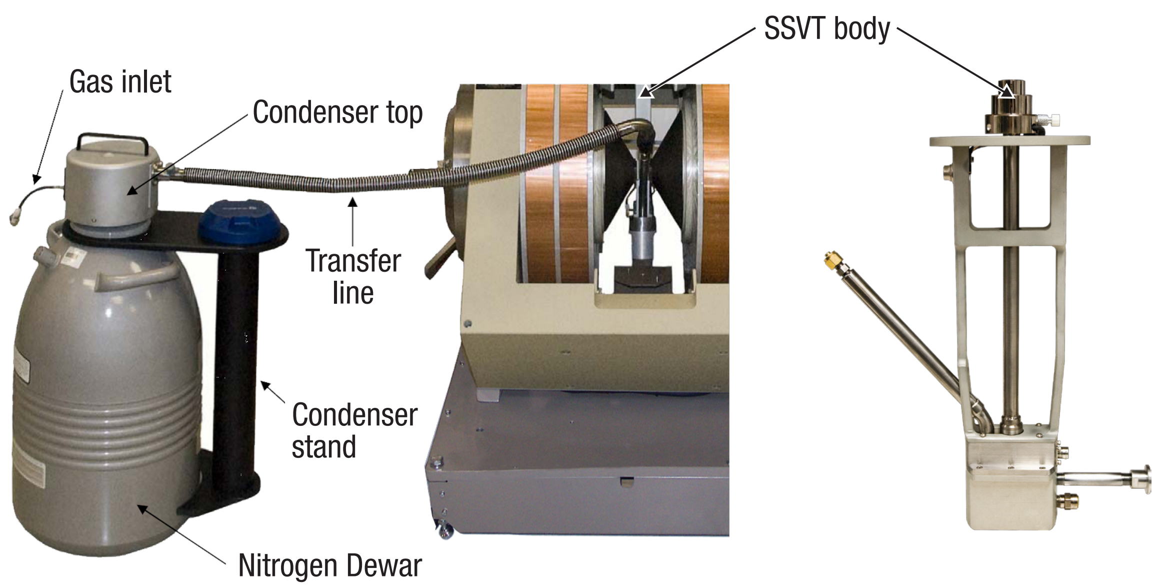
The purpose of this publication is to introduce potential users to the widest temperature range option for 7400 and 7400-S Series VSMs. Driven by the goal to provide researchers with a tool that makes wide temperature range experiments possible, we offer a variable temperature stage with one of the largest temperature spans for a commercially available VSM system. The base temperature is 78 K, and the controlled temperature range is 100 K to 950 K. We will present the advantages offered by the SSVT and an actual experiment performed in order to help illustrate the versatility of this temperature option.



The Model 74035 single stage variable temperature (SSVT) assembly is a continuous flow temperature device providing ranges of variable temperature operation between 78 K and 950 K. The SSVT design incorporates a flexible transfer line connecting a cooling condenser and a heat exchanger, allowing for both low and high temperature operation from a single temperature control device, without sample removal during a continuous sweep.

The table below presents the SSVT specification and requirements. Based on these data, we will explain in more detail the advantages offered by this temperature stage.

Model 74035 single stage variable temperature option		
Temperature range		78 K (base), 100 K to 950 K (control)
Temperature stability		±0.1 K (5 min)
Temperature accuracy		5 K below 500 K; 1% above 500 K
Temperature resolution		0.001 K
Cool-down time		15 min from room temp to 100 K, 40 min from 950 K to room temp
Nominal ramp rate (in the domain)		5 K/min
Temperature sensors		Type K thermocouples
Gasses		LN_2 and nitrogen gas for T<350 K; argon for T>350 K
Nitrogen gas usage		3.2 L/min 100 K to 350 K
LN_2 usage		<0.75 L/h >100 K to 350 K
Argon gas usage		3.6 L/min
Gas operating pressure		240 kPa (35 psi)
Vacuum requirement		0.67 Pa (5×10^{-3} Torr)
Noise, room temperature		1 μemu RMS
Sample zone dimensions	Bore size	7.1 mm (0.28 in)
	Outside diameter	17.8 mm (0.7 in)
Max outer surface temperature		75 °C
Uncrated weight		4 kg (8.8 lb)

For operation below room temperature, nitrogen gas is continuously cooled through a condenser immersed in liquid nitrogen. The cooled nitrogen gas/liquid is transferred through a vacuum jacketed, flexible transfer line to a vaporizer/heat exchanger at the bottom of the sample chamber. It is then vaporized and heated to the control setpoint. This gas travels upwards along the sample space to cool the sample and intercepts the heat load coming down the tube.

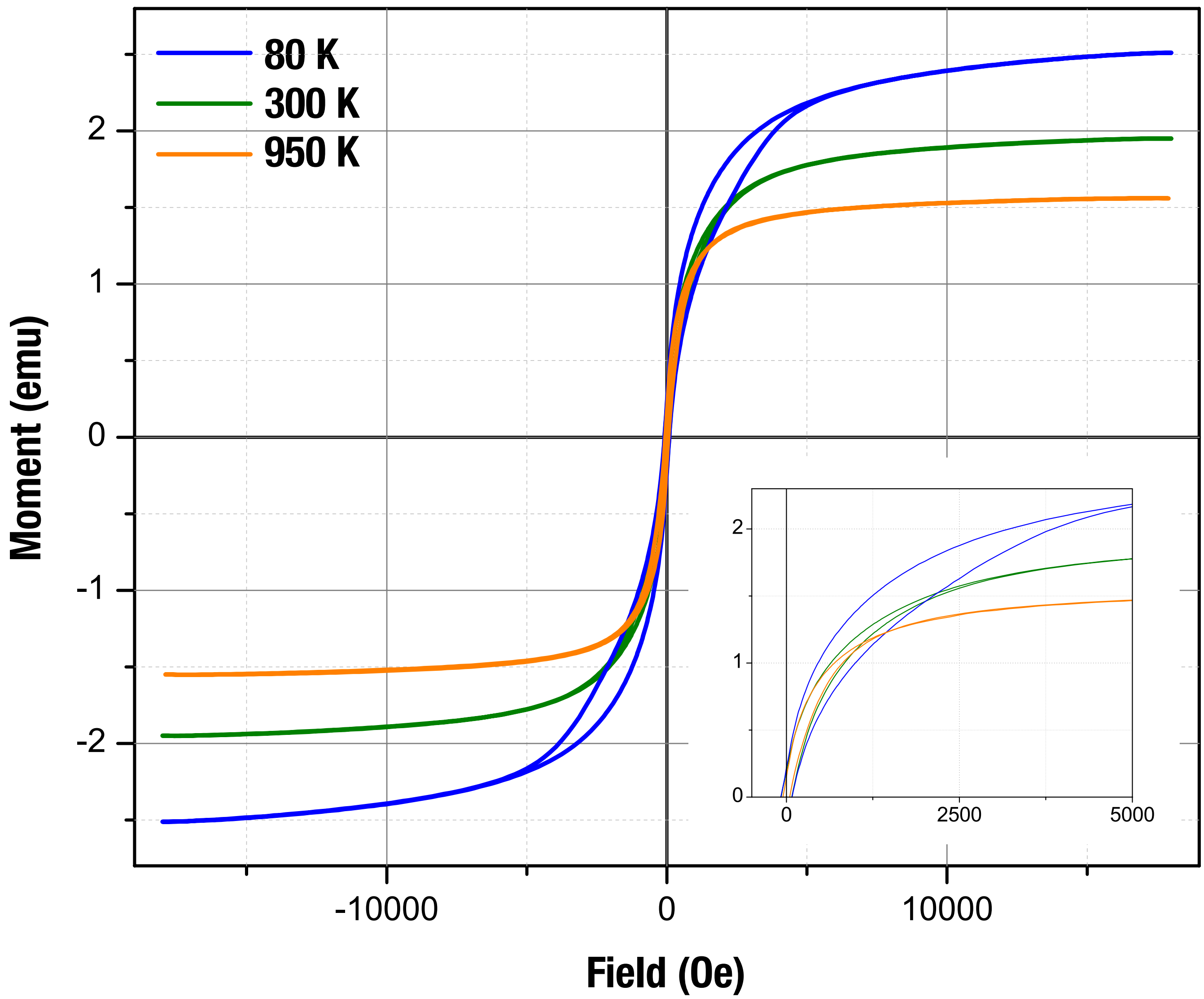
For operation above room temperature, argon gas is used and the condenser rests in a room temperature stand. In this mode, condensation is bypassed and room temperature argon is supplied to the heat exchanger, which transfers heat to the argon for elevated temperature operation.

Flow meters with control knobs (mounted in the gas handling box on the VSM drive support frame) control the quantity of gas/liquid supplied to the system. An active exhaust gas heater/cooler normalizes the temperature of exhaust air to prevent excessively hot or cold air from exiting the system during operation.

Temperatures above the liquid nitrogen boiling point are obtained by controlling the amount of coolant delivered to the vaporizer and the amount of current through a heater at the vaporizer.

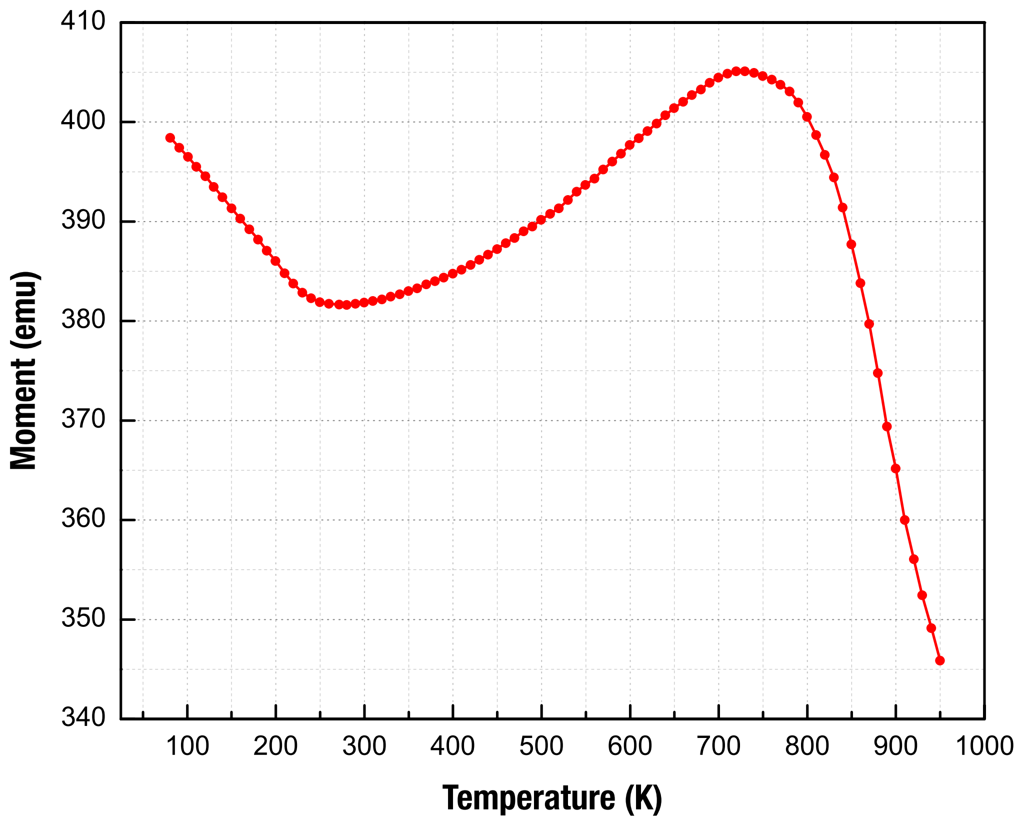
For our demonstration, we chose an alloy that has two different ferromagnetic (FM) phases with different crystal structures—martensite at low temperatures and austenite at high temperatures. The approximate alloy composition, by weight, is: Co 45%, Ni 39%, and Al 15%.

The sample was placed on a VSM boron nitride bulk cup sample holder and annealed at 900 K for 2 h with zero field applied to help relax the structure and eliminate any stress in the material. The annealing process was performed with the same SSVT temperature option that will be used in the following steps for the actual measurements. To measure the magnetic moment, we needed to apply a magnetic field and, based on the hysteresis curves measured previously, we choose to apply a 100 Oe field, close to the H_c (coercivity) value.



Hysteresis curves of a CoNiAl alloy measured at different temperatures

We then scanned the M vs. T starting from 950 K and ending at 80 K with an approximate cooling rate of 2 K/min, with a 10 K step.



Field cooling (100 Oe applied)—continuous scan done when cooling

We can observe a transition from FM austenite to paramagnet above T_C (Curie temperature). Usually T_C and TM (martensite to austenite transition) are very close. T_C and TM transitions can be easily detected by M vs. T measurements.

For the particular material studied, the transitions are at 275 K and 725 K. During the entire experiment, the sample was never removed from the temperature option and the whole experiment was performed in a single sweep. The total scan time was about 8 h.

This measurement demonstrates the SSVT's extended temperature range and ease of operation.

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Lake Shore Model 7407-S vibrating sample magnetometer

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