SC20 Magnetic Field Cancelling System

- **Protects your investment in electron beam technology by stabilising the magnetic field environment**
- **Cancels and monitors the field**
- **Simple "set and forget" operation**
- **Adapts to field changes within 100 µs**
- **AC or DC field sensors**
- **AC field cancelling from 0.5 Hz to 5 kHz 50 x field improvement at 60Hz (typ)**
- **DC field cancelling from DC to 5 kHz 200 x field improvement at DC**
- **Full 3 axis (X, Y, Z) system**
- **Up to 80 mG (8.0 µT) pk-pk cancelling range**
- **Supports multiple sensors for TEMs and CD metrology tools**

Overview

Today's high performance electron beam tools are very sensitive to changing ambient magnetic fields. The fields move the beam causing loss of resolution and measurement accuracy. The SC20 system stabilises the ambient field and restores the resolution and accuracy.

The SC20 system comprises a Magnetic Field Control Unit, one or two AC or DC Magnetic Field Sensors and three multicore cables which are installed in the room where the field is to be cancelled. The Control Unit power amplifiers drive currents through the cables to create a field which is the opposite sign to the changes in the ambient field. The magnetic field sensors measure the resulting field and real time negative feedback reduces the ambient field by the loop gain of the system.

The system is dynamic, automatically responding to field changes within 100 µs. Line fields (50/60 Hz) are reduced by 50 x and DC fields by 200 x.

SPICER CONSULTING, Eden Laboratory, Broadmead Road, Stewartby, Bedfordshire, England MK43 9ND
Tel: +44 1234 765773 Fax: +44 1234 765778 E-mail: enq@spicerconsulting.com Web: www.spicerconsulting.com

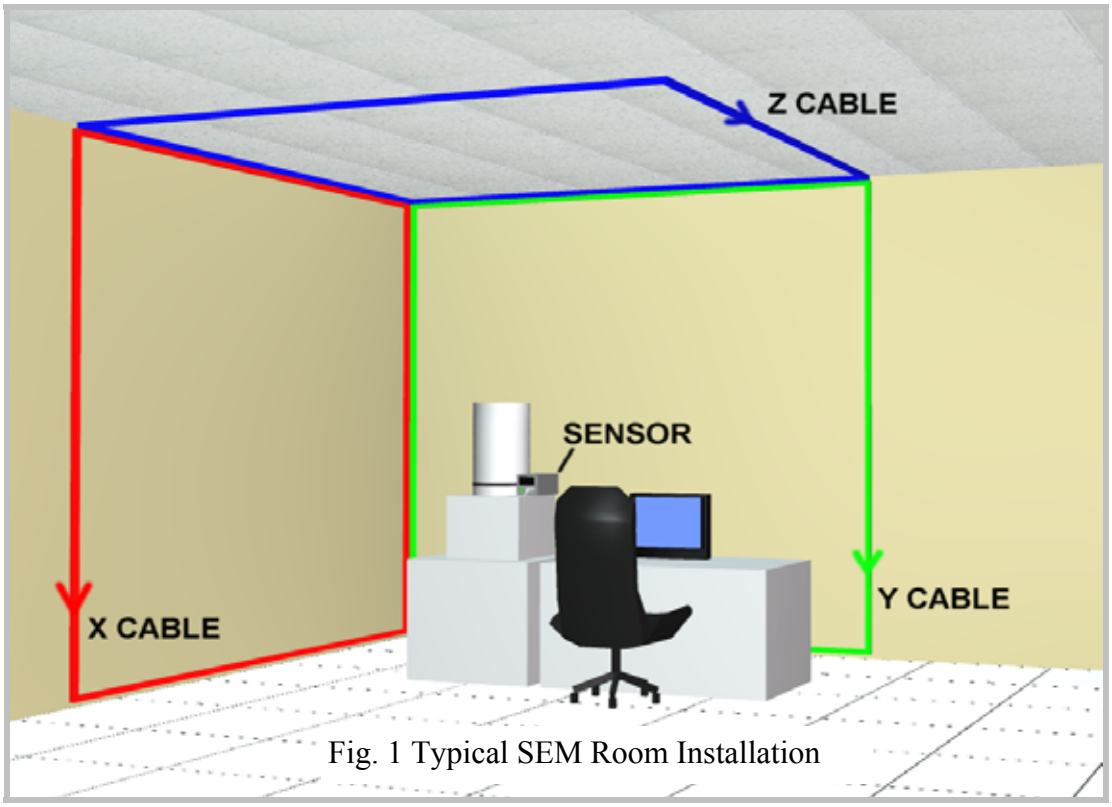

Fig. 1 Typical SEM Room Installation

Product Description

The SC20 is a third generation Magnetic Field Cancelling System, designed to improve the performance of electronic instruments that are sensitive to magnetic fields, such as electron microscopes and electron beam metrology tools.

It is important to note that mechanical vibration, acoustic noise and ground loops in the electron beam tool installation can produce imaging defects similar to magnetic fields. The SC20 system cannot improve images which are affected by these other interfering sources because they are not magnetic fields.

A typical SC20 AC system installation on an SEM is shown in Fig. 1. The control unit is not shown. The cables make one turn and are shown in red, green and blue. The actual cables are grey and usually installed in white plastic conduits. Where the room has a false ceiling, the Z cable is usually installed above it. The AC magnetic field sensor is located close to the bottom of the electron beam column. It is provided with a mount to enable it to be strapped to the column if required.

The amount by which the field is reduced is determined by the loop gain of the system, which depends on the details of the installation, but is typically 50 times. The system does not cancel the earth's magnetic field, nor does it cancel the field everywhere in the room. It creates a region around the magnetic field sensor where the field is much reduced. The volume of this region depends mostly on the gradient of the ambient field and the positioning of the field cables.

The SC20 control unit displays the amplitudes of the X, Y & Z field components and the total vector field on 3.5 digit panel meters. The meters display RMS field values. When the SC20 is used with the wideband DC sensor they can be switched to display incremental DC field values.

The real time measured fields are available on front panel BNC's as analog voltage levels for oscilloscope or chart recorder display.

The magnetic field amplitude is continuously monitored in the SC20 and compared with preset "trip levels" to provide "GO/NOGO" indication of the field quality. A large green LED on the control unit and a smaller LED on the sensor indicate that the field is "OK".

The controls used to set up the system are behind the drop down panel (Fig. 8) which is normally bolted shut. The general operation controls are on the front panel. The two grey front panel switches control the display meters and have no effect on cancelling. The five black switches disable cancelling and reset the system but can be locked out by a switch behind the drop down panel.

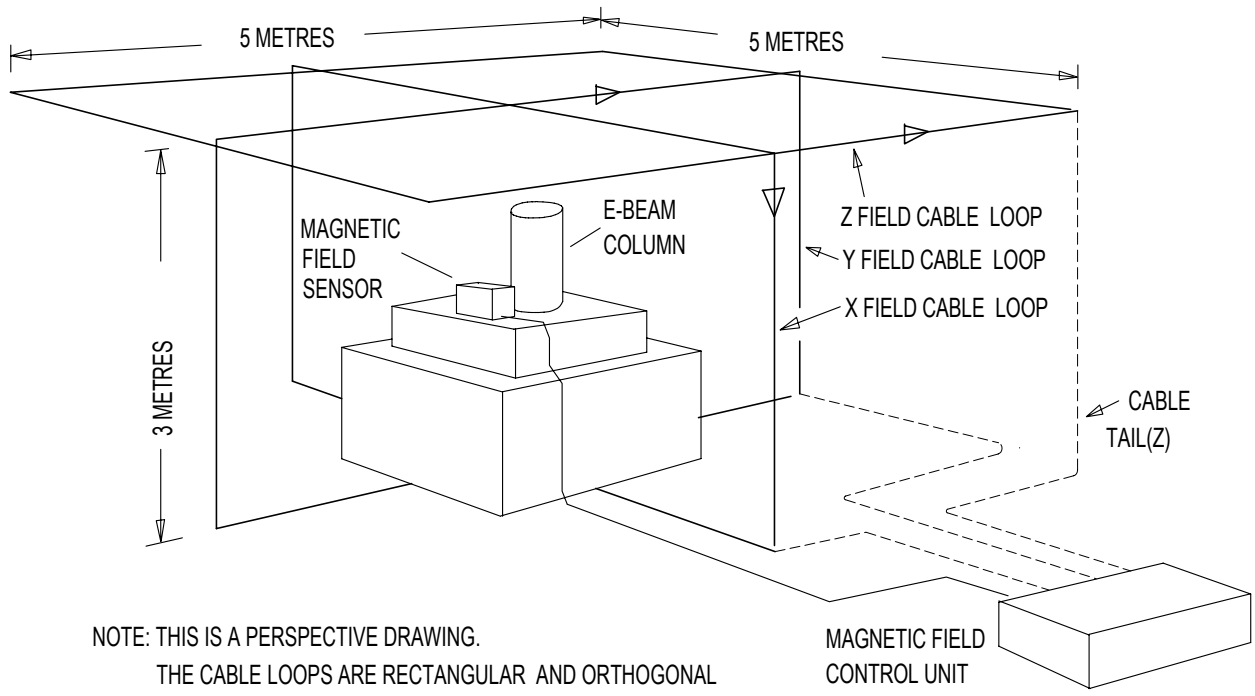

Fig. 2. Reference room installation

Installation options

The SC20 field cancelling cables are made with a loop and a tail. The loop creates the field and the tail (which makes no field) connects the loop to the control unit. The loop parts are shown in Fig. 1 in red, green and blue. SC20 room cables have X and Y loops 16 metres long and a Z loop 20 metres long. Longer cables are available to special order.

The Fig. 1 installation is suitable for most SEM applications where the electron beam column is typically 1.5 metres from the room walls. The maximum field which can be cancelled (the dynamic range) depends on the size and position of the cable loops relative to the electron beam column. With 5m x 3m X and Y loops and the column 1.5m from the walls the dynamic range is about 40 mG (4 μT) pk-pk.

For TEM installations the cancelled volume is important and customers are advised to consult Spicer Consulting support staff for design of the field cables.

When the room is large or in clean rooms where there are no local walls, alternative cable installations are possible. One option which has been used in semiconductor wafer fabs on CD metrology SEMs is to install the field cables under the clean room raised floor. The X and Y cables use a flat quadrupole configuration and they are custom designed for the particular installation. The dynamic range is less than the reference installation but the cables are effectively invisible to the customer. A similar cable configuration can be installed above a false ceiling if it is not too high. For these options, please consult Spicer Consulting support staff.

For OEM customers who wish to build the SC20 system into their electron beam tool, cables for Helmholtz coil installation are available. OEM customers should consult Spicer Consulting staff for applications support. Helmholtz cables are not recommended for general applications because the Helmholtz coil configuration requires a custom frame to be built around the electron beam tool, which severely limits access to the tool. The cancelling performance is generally inferior to room cables.

To specify the SC20 performance more rigorously, we use a reference cable installation geometry. This is shown in Fig. 2. The electron beam column is centred in the 3m x 5m X and Y loops (which cross over above and below the column) and the 5m x 5m Z loop. The SC20 specifications on page 5 apply to this reference room installation.

Fig. 4 SC20 AC Sensor

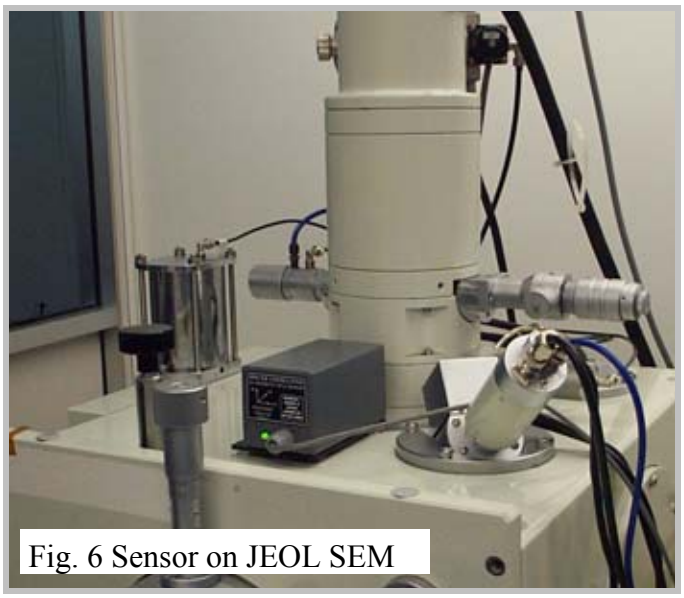
Fig. 6 Sensor on JEOL SEM

Fig. 5 SC20 DCMR Sensor

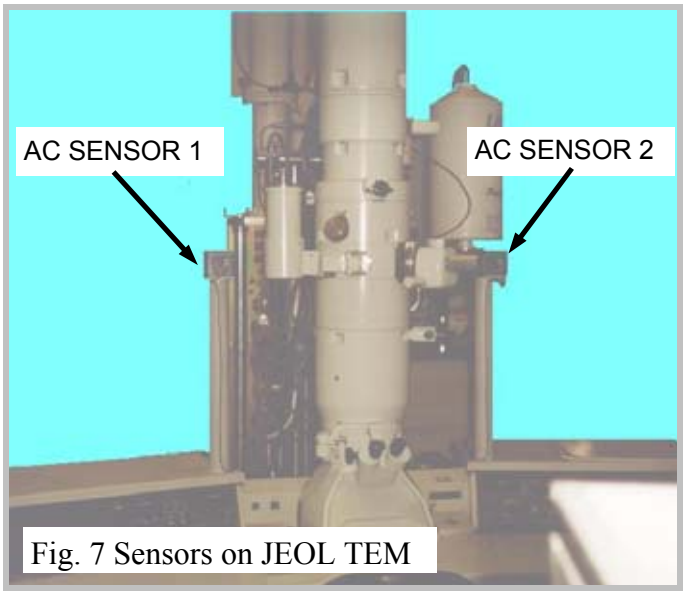

Fig. 7 Sensors on JEOL TEM

Sensor options

The AC and DC sensors for the SC20 are shown in Figs. 4 & 5. The SC20 can be used with one or two AC sensors or with one or two DC sensors. The most common configuration uses one AC sensor e.g. Fig. 6 and is used to cancel AC line fields.

When two sensors are installed e.g. Fig. 7, the mixer controls (Fig. 8) become active. The magnetic field outputs from the sensors are combined by the mixer to create a "virtual sensor" which can appear to be located inside the column. The mixer controls enable the apparent position of the sensor to be adjusted separately for the X, Y, and Z axes to tune the cancelling system for optimum improvement in the TEM imaging.

The SC20 can be used with two SC20 wideband DC sensors on CDSEMs to cancel the beam movement caused by the rotating magnets on nearby plasma etch tools in wafer fabs. The use of two DC sensors overcomes the problems of congestion in the cabinet (which makes it impossible to locate the sensors anywhere near the column). The mixer controls are used to tune the image movement to a minimum.

Fig. 8 Drop down panel with Mixer controls

Specifications

CO-ORDINATE SYSTEM	X, Y, Z rectangular Cartesian
UNITS	Gauss, Tesla (switchable)

FIELD CANCELLING

1. With SC20-AC sensor(s)

Components cancelled	X, Y, Z field components
Dynamic range (X & Y)	80 mG (8 µT) pk-pk (installation Fig. 2)
Dynamic range (Z)	60 mG (6µT) pk-pk (installation Fig. 2)
Field cancelling factor	50 X (typical) at 50/60 Hz
Bandwidth	0.5 Hz - 5000 Hz
Sensor 1/f noise limit (< 0.1Hz)	2 µG (0.2 nT) pk-pk
Sensor spot noise (at 50 Hz)	0.05 µG /√Hz (5 pT/√Hz)

2. With SC20 DCMR sensor(s)

Ambient DC field	± 2 G (± 200 µT) max
Dynamic range (X & Y)	± 40 mG (± 4 µT) incremental, (installation Fig. 2)
Dynamic range (Z)	± 30 mG (± 3 µT) incremental, (installation Fig. 2)
Field cancelling factor	75 X (typical) at 50/60 Hz 200 X (typical) at DC (incremental)
Bandwidth	DC - 5000 Hz
Drift (@23°C ±2°C, 2 hour warm-up)	DC drift/24 hours < 20 µG (2 nT)
ULF noise (0.0001- 0.01 Hz)	5 µG (0.5 nT) pk-pk (typical)
Sensor spot noise (at 50 Hz)	0.1 µG /√Hz (10 pT/√Hz)

FIELD MEASUREMENT

Types	Real time field AC - true RMS amplitude Incremental DC (with DC sensor)
Display	
RMS & DC	3.5 digit LCD panel meters
Sensor dynamic range	24 mG pk-pk
Meter range (reading) NOTE 1	0-19.99 mG (1.999 µT) RMS ± 19.99 mG (1.999 µT) DC
Accuracy NOTE 2	± 1.0 % of reading ± 10µG (1 nT) (DCMR sensor after 2 hour warmup)
X, Y, Z real time field outputs	
Scaling	1.0 V/mG
Range	± 12 Volts
Source resistance	10 kΩ
Connectors	3 x BNC
Bandwidth	5 Hz - 20 kHz (AC sensor) DC - 10 kHz (DC sensor)
Trip (AC & DC)	
Range of adjustment	0 - 2.0 mG (200 nT)
POWER	120/240 V 50/60 Hz, 100 VA

Note 1: RMS & DC measurement ranges are limited by sensor dynamic range
Note 2: sensors are calibrated with 50 Hz, 10mG RMS square wave field.

SPICER CONSULTING, Eden Laboratory, Broadmead Road, Stewartby, Bedfordshire, England MK43 9ND
Tel: +44 1234 765773 Fax: +44 1234 765778 E-mail: enq@spicerconsulting.com Web: www.spicerconsulting.com