Technolution

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The search for the ultimate picture

>>the Falcon electron detection camera

Biological matter is difficult to investigate with electron microscopes. It has very little contrast and deteriorates under the influence of electrons. However, a new type of sensor enables smaller amounts of electrons to be used, enabling more information to be obtained before the sample deteriorates. Based on this sensor, Technolution has developed a new camera for microscope manufacturer FEI.

FEI is a world leader in the manufacture of high-end electron microscopes. Using transmission electron microscopes (TEM), it is possible to distinguish details that are less than one Ångström (10-10m) in size. These microscopes are used in the electronics industry, the biomedical sector and research institutions.

In a TEM, the electrons pass through the slide just like the light in an ordinary (light) microscope or slide projector. Electromagnetic lenses enlarge the beam and focus the slide onto a camera which sends the images to a PC.
Biological matter displays very little contrast in a TEM and deteriorates rapidly when subjected to electron radiation. In biological research, low doses of electrons are preferred, although with conventional cameras, this results in a poor signal-to-interference ratio and low resolution. For this reason, FEI has ordered the design of a more sensitive CMOS sensor in order to directly detect electrons.

From sensor to direct detection

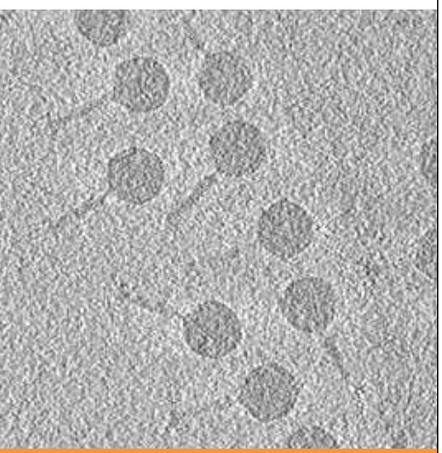
In conventional TEM cameras, a scintillator converts the electrons into light which is then registered by the sensor. This conversion process is necessary to protect the sensor from the electrons, although it results in inefficiency and lower resolution. The new sensor has been specially designed to reduce the influence of direct lighting with electrons, making it much more sensitive. As a result, with the same quantity of electrons, you can create three times as many images that are equal in quality to those of regular sensors. Equally, you can use one-third of the usual quantity of electrons to create the same amount of images as with a regular sensor.

From sensor to camera

A sensor is not the same as a camera. The key to turning a sensor into a camera is signal processing. However, the right casing is also important. The sensor is a large 16 megapixel silicon chip, provided on a printed circuit board which must fit completely into the TEM's existing sensor chamber. The physical space available for electronics is therefore extremely limited. By wire bonding the sensor directly onto the print, the space is used far more efficiently. Furthermore, the high vacuum in the sensor chamber demands careful design of the printed circuit board in order to prevent contamination of the vacuum. Furthermore, it must be possible to extract the sensor from the sensor chamber in order to make room for a second camera: this requires flexible PCB technology. And of course, strict requirements also exist regarding transmission of the sensor output. In order to comply with these requirements, simulations and field-solving techniques are employed which analyse and optimise the function of the analogue signal pad..

Vacuum and cooling

As mentioned earlier, electron microscopes work in high vacuums, which results in additional technical challenges. The electron microscope works in a high vacuum to prevent scattering of the electron beam. The sensor is also located in the vacuum, which makes cooling a challenge. Cooling is necessary to improve the signal-to-interference ratio. The sensor is cooled using a Peltier



element, and the heat is conducted away by water.
Due to the limited cooling and space, the necessary electronics must be kept out of the vacuum as much as possible. The camera is read out on a vacuum-compatible printed circuit board. The raw image data is transmitted directly through the vacuum chamber, whereupon it is digitised and transmitted from the camera via a 10GB fibre-optic cable. The cable carries the data to an external processing unit, which processes the image.

Image processing

Each pixel is calibrated separately with regard to offset and gain. With such a large chip (4K x 4K = 16 megapixels), the chances of defective pixels are high. However, the software can compensate for this. The algorithms are run by the TEM software installed on the operator's PC. Ultimately, the operator decides which settings are used. Due to the large volume of pixel data, it is not possible to run these algorithms on a standard PC. These algorithms are therefore run in a separate processing unit. The processing unit reduces the 10GB data flow in order to make it compatible for PC use. The processing unit is connected to FEI's PC via a standard 1GB Ethernet connection, and this PC operates a software module that communicates with both the processing unit and the PC's own software.

New experiences

It was a new experience for Technolution to fundamentally examine the physics and technology at such an early stage in the product's development. We not only investigated how the sensor worked, but also the entire TEM technology that surrounded it. The project was particularly interesting as we investigated complex questions on the cutting-edge of modern innovation, such as how the components and factors such as electron radiation, X-rays, vacuums and vibrations affect one another, and how the design can be optimised within the constraints of this environment. In order to develop and manufacture the mechanics (the camera casing), Technolution worked together with Demcon. Technolution played the lead role in the project, developing the electronics, the software and the programmable logic. We also created a life-cycle-management plan to ensure that the new camera remains properly maintained for years to come.

The complete picture is important to FEI, and as such, they have maintained intensive contact with their clients in order to monitor their needs and desires. And with the new electron detection camera, the company has a powerful tool to further optimise the service they provide to their customers.