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ELECTRON MICROSCOPE AS FORENSIC TOOL

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Abstract

Electron microscopy is a basis of the modern forensic laboratory. Combining high resolution, increase depth of field, and brilliant magnification. The scanning electron microscope (SEM) offers unparalleled views of small to trace the materials. Additional analytical equipment offering elemental, chemical, and structural analysis makes the SEM requisite to forensic scientists. It becomes possible to make conclusive identifications of the origin of some materials and thus contribute to the chain of evidence because of the ability of SEM to analyse the elemental composition of even the smallest features on specimens. The SEM is, therefore, a major tool in forensic research and investigation.

Keywords:

INTRODUCTION

Electron magnifying instruments make utilization of electrons as opposed to photons to frame their picture. The transmission electron magnifying instrument (TEM) was created first, pursued a few years after the fact by the filtering electron magnifying instrument (SEM). Transmission microscopes are for the most part more hard to utilize and require more meticulous sample preparation than SEM and in this manner have discovered not very many applications in legal science. Since the SEM just takes a gander at the surface of a sample, test readiness is regularly substantially less complex and much of the time comprises basically of putting the example on a bit of conductive carbon tape. It might be important to vacuum store a layer of carbon or gold over nonconductive samples to make them conductive, in spite of the fact that the new 'ecological SEMs' can picture nonconductive examples in a low vacuum. SEMs are presently being used in numerous criminological research facilities around the globe. The greater part of these magnifying instruments are outfitted with vitality dispersive X-beam spectrometers for essential investigation. X-beam spectrometers gather the X-beams which are delivered alongside the optional and backscattered electrons when an example is besieged in a vacuum with electrons. These X-beams are gathered and after that arranged in a multichannel analyser as indicated by their vitality which is straightforwardly identified with nuclear number. Both subjective and quantitative investigations can be performed on minute samples from boron as far as possible up in the intermittent table. As far as possible for every component fluctuates, however ordinary cutoff points of location for most components, barring a portion of the light components, is around 0.1%. One of the principles employments of scientific SEMs in legal science research facilities is the location and investigation of gunfire deposit (GSR) particles. Conductive sticky tape, appended to the back of an example stub, is squeezed over a presume's hands to gather any deposit which may be available. The stub is put in the magnifying instrument and looked, either physically or consequently, for particles with a circular morphology which contain lead, antimony and barium. The blend of the round morphology with this basic structure gives better confirmation of the nearness of GSR than a natural examination alone. Different kinds of minute proof which can be analyzed in the SEM incorporate things as assorted as dust grains, diatoms, paint, glass, inorganic explosives and general questions. The joined capacities of the SEM to determine fine structures and give the essential organization of these little particles is a huge guide in the examination of numerous little things of follow proof.

Scanning electron microscopes (SEM) provide forensic investigators with critical imaging and analytical capabilities that are not available from other techniques. In particular, they can resolve features as small as a nanometre, allowing useful magnifications of 100,000 times or more.

Even at very high magnifications, scanning electron microscopes have large depth of field, allowing them to capture well-focused images of complex three-dimensional objects. In conjunction with X-ray microanalysis, they can determine the elemental composition of the samples as small as a few micrometres or map the distribution of elements in larger samples with micrometre spatial resolution. They are widely used for the analysis of gunshot residue; tool mark investigations; ink and paper analysis; paint, hair, and fiber matching; and the identification of other trace evidence, such as pollen and diatoms, that can link a suspect to a crime scene.

SEM-IMAGING

Unlike optical microscopes, which form a real image from transmitted or reflected light, a scanning electron microscope forms a virtual image on an electronic display. A finely-focused beam of electrons scans the sample surface in a raster pattern and the brightness of each point in the displayed image represents the strength of the imaged signal generated at the corresponding point in the sample when it is illuminated by the beam.

The imaged signals are created by interactions between beam electrons and sample atoms as the beam penetrates into the sample. The depth of penetration is determined by the accelerating voltage of the beam and the density of the sample, and ranges from a few nanometres to a few micrometers. SEM is generally regarded as a surface imaging technique. Different interactions yield signals, each with different characteristics. The most common signals include: secondary electrons (SE), used primarily for high resolution and high topographic contrast; backscattered electrons (BSE), used for material contrast (atomic number); and characteristic X-rays, used to determine elemental distribution and composition. Due to its superior performance, SEM is used in an increasing number of various applications and give best results.

- Gunshot residue analysis
- Firearms identification (bullet markings comparison)
- Investigation of gemstones and jewellery
- Examination of paint particles and fibres
- Filament bulb investigations at traffic accidents
- Handwriting and print examination / forgery
- Counterfeit bank notes
- Trace comparison
- Examination of non-conducting materials
- High resolution surface imaging

Forensic Applications

Measurable uses of SEM are found most in forensic science where there is a requirement for good imaging at generally high amplifications in mix with elemental analysis. This is the situation in zones where little particles of moderately heterogenic character and with a complex arrangement have a important influence, for instance gunshot residue and pyrotechnical post-blast deposits. In other areas where there is no special need for imaging at high magnification and elemental analysis, or wherethere is a need for information that SEM doesn't provide, for example colour, SEM is not the preferred technique.For example, in the forensic examination of fibres SEM is only used sometimes to investigate fiber fracture anddamage. Also, for the forensic examination of biological samples SEM isn't used very often.

Analysis of micro traces in invasive traumas

SEM microscopy in blend with vitality dispersive X-beam spectrometry (SEM/EDS) is a demonstrated measurable instrument and has been utilized to dissect a few sorts of follow proof. A legal use of SEM/EDS is the examination of morphological qualities of hardware denotes that devices and instruments leave on bone. The microtraces that are abandoned by these apparattus and instruments on the bone are, in any case, frequently disregarded or not saw by any stretch of the imagination. In this paper we will portray the utilization of SEM/EDS for the investigation of microtraces in obtrusive sharp-compel, limit power and bone-hacking injuries in bone. This exploration is a piece of a bigger multi-disciplinary methodology in which pathologists, scientific anthropologists, toolmark and microtrace specialists cooperate to interface watched wounds to a presumed weapon or, if there should be an occurrence of an obscure weapon, to demonstrate a gathering of items that could have been utilized as a weapon. In spite of the fact that there are a couple of troubles one need to consider, the strategy itself is fairly basic and direct to apply. An example of dry and clean bone is put into the SEM test chamber and brilliance and complexity are set with the end goal that bone seems dim, metal seems white and natural material seems dark. The example is then sought physically to discover pertinent highlights. When highlights are discovered their basic synthesis is estimated by a vitality dispersive X-beam spectrometer (EDS). This technique is shown utilizing a few cases. It is demonstrated that SEM/EDS examination of microtraces in bone is a profitable device to get pieces of information around an obscure weapon and can connect a particular weapon with wounds based on appearance and natural synthesis. Specifically the different outcomes from the different orders are integral and might be joined to achieve a determination with a more grounded probative esteem. This isn't just valuable in the court however most importantly in criminal examinations when one needs to know for what weapon or question search for.

Diagnosis of electrocution

Passings from power, for the most part, don't have particular discoveries at the post-mortem.. In this way, there is an incredible enthusiasm for discovering particular markers of electric shock. The look for the metallization of the skin through Scanning Electron Microscope furnished with Energy Dispersive X-Ray Spectroscopy (EDS) test is of exceptional significance so as to accomplish a distinct finding if there should arise an occurrence of associated electrocution.n the doubt with electric shock, the coordinated utilization of various devices is suggested, including plainly visible perception, H&E recoloring, press particular recoloring, filtering electron microscopy and EDS microanalysis. Just the cautious elucidation of the outcomes given by every one of these strategies can enable the pathologist to accurately distinguish the reason for the passing. Especially, the present examination proposes that the microanalysis (SEM-EDS) speaks to an exceptionally helpful apparatus for the conclusion of electric shock, permitting the discovery and the distinguishing proof of the metals implanted in the skin and their assessment with regards to the ultrastructural morphology

Post explosion residues

Improvised explosives may be based on pyrotechnic mixtures and these can leave behind distinctive explosive residues which in turn contain clues about the attack, such as the Bali bombings [4]. Production, sampling and analysis of post explosion residues (PER) from pyrotechnic compositions are all very similar to that for GSR.SEM is the preferred technique for the detection and classification of post-explosion residues from these kind of compositions (figure 5), while LC/MS (after swabbing) is the preferred technique for PER from organicexplosives. Attempts to use SEM for the latter kind of PER are unknown.

Fibers

Fibers give a standout amongst the most widely recognized and critical kind of trace evidence recovered in scientific examinations. They are exchanged starting with one surface then onto the next regardless where contact has happened and may have very high evidential qualities to connect people and areas. Filaments are inspected in two stages: identification (characterization) and comparison. Recognizable proof or characterization of a fiber is a precursor to its examination, regardless of whether to a known source or to other addressed strands. These examinations incorporate a plan of investigation utilizing physical, optical, and compound properties. Instrumentation helpful in fiber examinations incorporate microspectrophotometers (MSP), vitality dispersive X-beam microanalysis (SEM-EDX), SEM is once in a while used to research fiber break and harm.

Tool marks comparison of a wire cut ends

SEM electron picture has been broadly used to consider the geographical picture of the cut finishes cross segments of wires found at the scene of wrongdoing in appalling wrongdoing cases. The land data got from auxiliary electron picture in SEM results in the sharp and centered striations which empower us to look at the striations found on the cut end crosswise over segments. The unrivaled profundity of center with high amplification SEM is in charge of the investigation of the ultra fine structures between striations

Ballistics

The examination of micro traces of foreign materialembedded in or adhered to bullets provide critical information in the trajectory reconstruction of spent bullets. The check of a ricochet by examination of remote material can have significant legitimate ramifications, since this confirmation can demonstrate that it wasn't somebody's expectation to murder [5]. Then again, hints of lead or metal found on harmed items can demonstrate that the question was hit by a slug. In an ongoing report it was demonstrated that milder slugs (lead) are more vulnerable to exchange of material than harder shots (Full Metal Jacket, this metal). From the result it likewise pursues that it is conceivable to redirect the request of effect from the stratification of the outside material analysed.

Forensic pathology and anthropology

The morphological examination of cut injuries may frequently not be sufficiently precise to interface it with the kind of injuring weapon, however a further assessment might be performed with the look for metallic deposits left amid the contact between the instrument and the skin. At the NFI the SEM is oftenaround pathology and anthropology to reveal microtraces of metalsand other materials from murder weapons in the invasive traumas of victims and to visualize saw and tool markson bone.In one particular case a missing person was eventually found buried. A large part of the skull was missing,especially the frontal part . Three incomplete circular fractures were found. The forensicanthropologist believed that the women was shot with large caliber ammunition, like Brenneke. However, nogunshot residues, traces of lead or bullet fragments were found. Only a chip of chromium was found in the hair of the victim. After a while it was decided to investigate also the non-circular fractures. Small traces of metalwere found in the lines of fracture Both the chip and the traces of metal in the skull had the samestructure and composition. Probably chip and traces had the same origin. Later an admitting speculate declared that he killed the individual with a bike bolt The bolt was found close to the scene of wrongdoing and appeared to have an upper layer with indistinguishable structure and creation from the chip found in the hair and traces in the fractures. The round handles on the bolt could have caused the roundabout breaks in the skull.

In another case the skeleton of a missing person was found under aconcrete floor while renovating the building. In the back of the skull also called gutter wound was found. In the upper two vertebrae tracesof lead were found at several locations. Probably the victimwas killed by a shot in the back of the neck. In some of the lead foundat the vertebrae also a little glass microfiber was found, indicating that the shooter has used improvised silencer

3D-applications

Our eyes see slightly different views of an object in front of them. The apparent position of an object in the two views is different by an amount, known as the parallax P. Our brain converts this parallax P to depthinformation. Viewing an object from two different viewpoints is equivalent to taking two images from a singleviewpoint but rotating the object.This procedure is usually employed in the SEM:two images are recorded fromthe same area of a specimen, but the sample is tilted between exposures.To visualize the depth in the imagesone image is printed in green and the other in red on top of each other. The combined image is called an anaglyph and is viewed through coloured glasses to separate the images at the eyes

The Forensic Comparison of Soils

In the primer investigation by M. J. Mcvicar and W.J. Grave, the writers built up a dirt investigation technique in light of the computerized molecule pursuit and order capacities of a filtering electron magnifying instrument outfitted with a vitality dispersive x-beam spectrometer (SEM-EDX). Creative example planning amplified scattering and thickness of soil particles while yielding exceptionally agent subsamples. The mechanized SEM-EDX conspire, while closely resembling customary soil investigation by optical mineralogy, does not experience the ill effects of a portion of the genuine impediments related with optical strategies. The investigation of soils by SEM-EDX is quick and dependable, requiring little intercession by the inspector once mineral classes have been characterized, though examination by optical mineralogy is to a great degree tedious and requests the expertise of an analyst exceedingly prepared in the utilization of a pétrographie magnifying lens. Computerized examination not just orders soil particles substantially quicker than a human expert, yet in addition permits an enhanced target factual proportion of soil likeness or distinction. The capacity of the robotized framework to effectively separate distinctive soils, yet to 'perceive' imitate tests, was effectively illustrated. As a further favorable position, computerization licenses chronicling of the crude information for re-translation as new mineral classes are added to the order conspire. The fundamental outcomes demonstrated that mechanized investigation gives adequate separation tantamount to, or superior to, can be accomplished by optical mineralogy.

Gunshot Residue Analysis (GSR)

For GSR analysis, specimens are typically collected using double sided tape and transferred to an SEM specimen stub. The system conducts a completely automated search over the stub for particles greater than e.g. 0.5 µm. Particles are automatically detected due to their high contrast with the stub background, using a detector for backscattered electrons. When a particle is detected, the electron beam is returned to the particle for X-ray analysis to check for predetermined elements. If a positive identification is made, the position of each particle is stored for later verification. In general, this automation routine is conducted using an EDS system connected to the SEM. In order for this automation to be successful, the EDS system must be able to remote control the SEM especially the electron beam and stage with long term stability, speed, accuracy and precision, which all of Zeiss SEM series routinely deliver. The new high precision stages have been built to a high level of accuracy. This means that the user can easily return to previously detected particles for further analysis and verification.

Shooting-Distance

During the investigation of a shooting, there are usually several different perceptions of what happened. Elements such as the struggle over a firearm or where the victim and shooter were standing in relationship to one another are questions that need unbiased answers.

Firearm examiners routinely examine a shooting victim's clothing for bullet holes and other evidence that may determine the distance from the muzzle of the firearm to the clothing. Determinations are made as to which holes are bullet entrance holes and which are bullet exit holes. The area around bullet entry holes are examined for patterns of gunshot residues. If residue patterns are detected, then these are compared with test targets produced by firing the firearm in question at various known distances which allows the examiner to approximate the distance from the object that was shot to the muzzle end of the firearm.

Shooting distance investigations are normally carried out using wet chemicals. In using these chemicals, a colouring will appear if firearm discharge residue (FDR) particles are present, such as gunshot residue (GSR). Often, however, such tests are destructive, so the evidence is no longer available for cross examination.

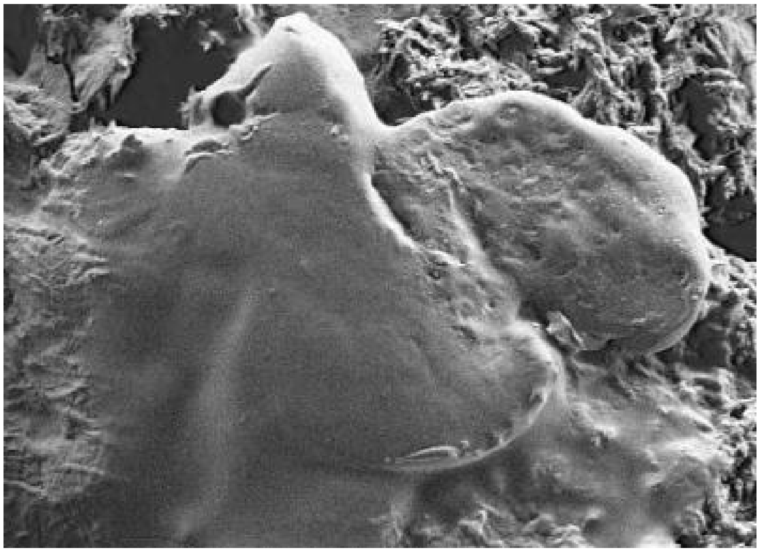
By using the SEM's low vacuum mode, the uncoated sample can be easily investigated for bullet wipe or patterns around the bullet hole. A special software routine scans the sample for particles, stores all images, and even performs real GSR analysis. By scanning in cross-mode, within minutes an overview is made of all present particles. The indicated distribution helps to determine the shooting distance.

Bullet Comparison

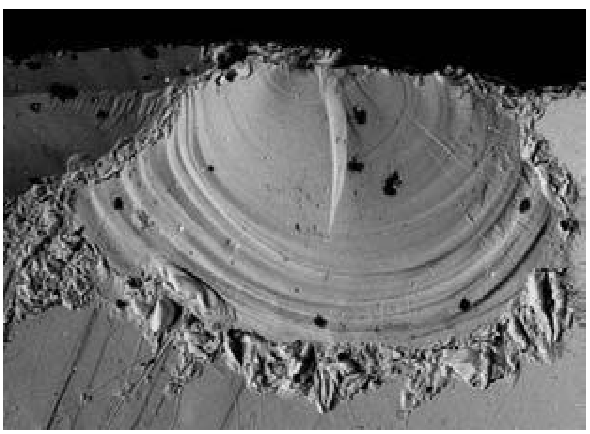
Bullets fired from the same weapon carry distinct markings which are related to the shape of the barrel of the gun. Furthermore it is possible, by matching the characteristic markings on bullets, to conclude whether they were fired by the same gun. Similar markings are made by the firing pin on the cartridge case of the bullets, permitting another method of relating a bullet to a particular gun. Bullets may sometimes be matched using optical techniques. However, optical microscopy lacks the ability to reveal fine detail seen at higher magnifications, and the depth of focus to show it clearly.

Examination of Non-Conducting Materials

One of the traditional drawbacks of conventional scanning electron microscopy is that specimens must be conductive. Non-conducting materials need to be coated with a conducting material, such as gold or carbon. Coating is especially undesirable in forensic examination, as it is important for evidence to remain unaltered. This is no longer the case using our SEMs with VP or EP mode. These features allow the user to adjust the chamber pressure to a level which prevents the specimen from charging since the chamber atmosphere itself dissipates the charge. Even completely non-conducting specimens such as paper, paint, textile tissue, hair or plants can be examined at low kV and analysed using EDS without the need for specimen preparation thus preserving the sample in its natural state. The same is also true for moist or even porous specimens such as concrete or bone. SE-imaging and EDS-analysis clearly shows the difference between diamond, an insulator, and its synthetic substitute moissanite being a semiconductor.

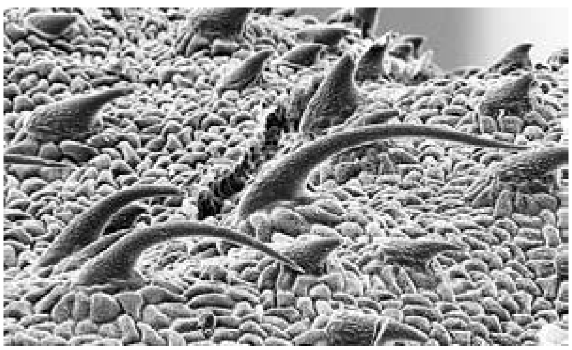


Ball-pen paste on laser printed document in the SUPRA™ 55. HV mode, 1 kV. No toner particle visible on the ball-pen paste is the proof of no falsification.



Variable Pressure image: Glass (uncoated).

Hair root showing the follicular tag piece of skin used to show whether hair was forcibly removed from the scalp follicle (uncoated).



One side of marijuana leaf (the bear-claw shaped trichomes aid in identification).

CONCLUSION

The ability of SEM to provide both high resolution imaging and compositional analysis makes it an excellent tool for forensic investigations. It is already well established for applications such as the analysis of gunshot residue, shooting distance, tool marks, and trace evidence**.**

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