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Full Length Research Paper

Study on interfacing of a nano-chip with brain tissue

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The brain slice can be placed on the perforated substrate of the chip that is supplied with nutrients, drugs and gas from both above and below. The nano–electrode (chip) can be used as a shape for larger contact area and stronger interaction with the brain tissue. These electrodes could penetrate the brain slice without damaging the tissue too much. There are two significant issues in nano-chip: oxide and silicon, which can threaten the tissue system, because they can make unwanted bonds and as a result, affect the brain tissue. We thus heated nano-chip in the ultra high vacuum (UHV) by passing current through the sample and could get a clean nano- chip without silicon and oxygen. The obtained results show that the tilted electrode may damage brain tissue more than the untilted electrode and so, the tilted electrode should not be used in brain treatment, because the porosity of the electrode may be filled with undesirable materials.

Key words: Nano–chip, brain tissue, backscattered electrons yield.

INTRODUCTION

The ongoing race to study nano device below 1-5 nm has led to a search for a suitable nano-chip. This material is already entering the fabrication of nano-electronic and biological devices. Today's developments in genetic engineering, nanotechnologies and material sciences have paved the way for new scenarios in highly complex systems to interface the human nervous system. Combinations of neural cells with microimplants are promising interfaces of stable biohybrid. Nanotechnology opens the door to macromolecular landscapes on implants that mimic the biologic topology and surface interaction of biologic cells (Bahari et al., 2006; Bartels et al., 2007; Buchs and Muller, 1991; Carpick and Salmeron, 1997; Chiu et al., 2007).

A wide range of micro fabrication techniques has been developed to produce miniature components and devices with micrometer-scale resolution. Although most of these techniques were initially developed for the semiconductor industry to fabricate integrated circuits, they have been adopted and modified to manufacture a large variety of tools and materials for biological research (Chiu et al., 2007).

This information is viewed as an image on a SEM screen, so that the elastic and inelastic scattering interactions can reveal information on the specimen's composition, topography, crystallography, electrical potential, local magnetic field and other properties. An energy depressive x-ray spectrometer provides the analyst with a view of the entire x-ray spectrum, so that many elements can be mapped in parallel with the same area and the x-ray maps compared. Unfortunately, the generation and detection of x-rays varies strongly with photon energy, thereby complicating any direct comparison greatly.

We studied a nano-chip by using SEM for capability of the chip for brain treatment. The images demonstrated that the thin silicon over the chip's layer can cause some unwanted bonds with oxygen and carbon and therefore damage the system.

Chip surface features

When 30 keV (or lower-energy) primary electrons first entered the SEM specimen, they were scattered elastically (by Coulomb interaction with atomic nuclei) and inelastically (by interaction with atomic electrons). Although inelastic scattering does not contribute to the backscattered signal, it reduces the kinetic energy of the primary electrons until they are eventually brought almost to rest and are absorbed into the solid (in a metal specimen, they would become one of the conduction

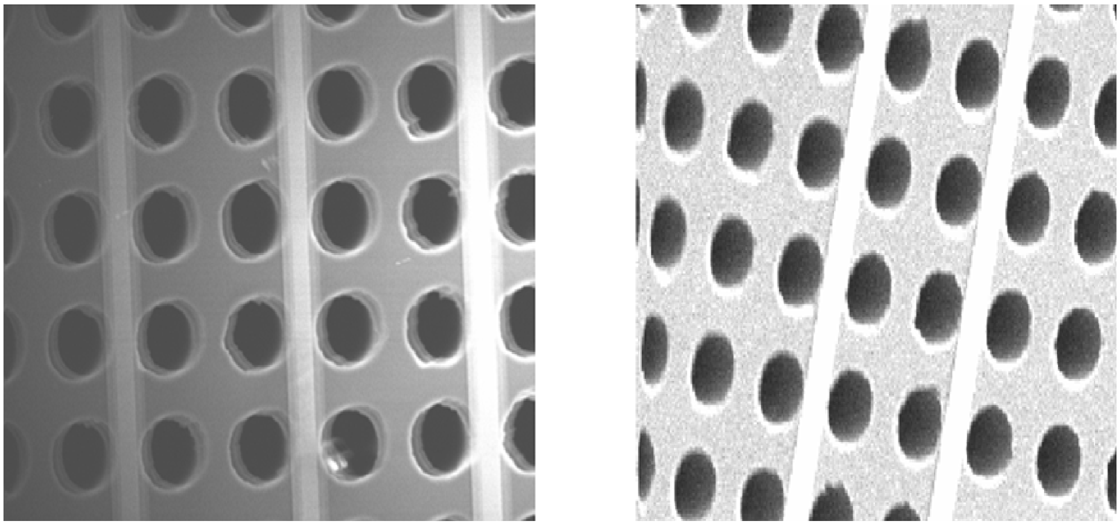

Figure 1. Dependence of SE yields on the angle of tilt (right) relative to the primary-electron beam (zero angles correspond to perpendicular incidence (left)). Data points represent experimental measurements for chip.

electrons). From conservation of energy, we can expect that one or more of the atomic electrons gain the energy that was lost by a primary electron in an inelastic-scattering event. If these electrons are outer-shell (valence or conduction) electrons, that is, are weakly bound (electrostatically) to a nucleus, this acquired energy may enable them to escape from the confines of a particular atom and travel through the solid. In doing so, these excited electrons will also be scattered inelastically and as a result, they will gradually lose their excess energy. Most of the atomic electrons acquire a kinetic energy of less than 100 eV, and since the probability of inelastic scattering increases with the decreasing electron energy, the distance the low-energy electrons can travel in the solid is very small (typically one or two nm on average). Most of them are therefore brought to rest properly within the excitation volume. However, any electron that receives its excess energy in a scattering event which takes place very close to the surface, and which is travelling in the right direction (momentum towards the surface), may escape into the vacuum as secondary electrons. These electrons are generated within very small depth (<2 nm) below the surface, known as the escape depth (Fromherz and Leffet, 1996; Morales et al., 2002; Seiple and Pelz, 1994; Vincek et al., 2003).

The average number of the secondary electron produced per primary electron is called the secondary-electron yield Y and is typically in the range of 0.1 to 10 (varying between different materials). For a given sample material, Y decreases with increase in incident energy E0, since the probability of inelastic scattering of a primary electron within the escape depth decreases. We should not forget that surface features, tilted towards the detector, appear particularly bright because electrons that emitted from these regions have a greater chance of being collected. It gives a characteristic three-dimensional appearance to the SE image and makes the topographical contrast relatively easy to interpret from analogy with a rough surface, which is obliquely illuminated by light. As Figure 1 indicates, the secondary-electron yield also depends on the angle between the incoming primary electron and the surface. Its value is lowest for normal (perpendicular) incidence and increases with the increasing angle between the primary beam and the surface-normal.

The reason for this is illustrated when a parallel beam of primary electrons incident is focused at two locations on a specimen, where the surface is normal and inclined to the incident beam. The volume from which the secondary electrons can escape is that which lies within the escape depth of the surface, measured perpendicularly to the surface. This escape volume, and therefore the SE yield Y, is greater for inclination by a factor of 1/cosɵ, where ɵ is the inclination of the surface (relative to the case of normal incidence) (Fromherz and Leffet, 1996; Morales et al., 2002; Seiple and Pelz, 1994; Vincek et al., 2003).

On the other hand, the backscattered (BSE) signal is extremely useful for finding different phases present in tissue specimens. In practice, the backscattering coefficient (the fraction of primary electrons which escape as BSE) does increase almost linearly with atomic number for low Z, while BSE images therefore tend to portray the chemistry of the specimen, whereas SE images reflect mainly its surface topography.

Since this elastic scattering involves only a small energy exchange, most BSE's escape from the sample with energies is not too far below the primary-beam energy. The secondary and backscattered electrons can therefore be distinguished on the basis of their kinetic

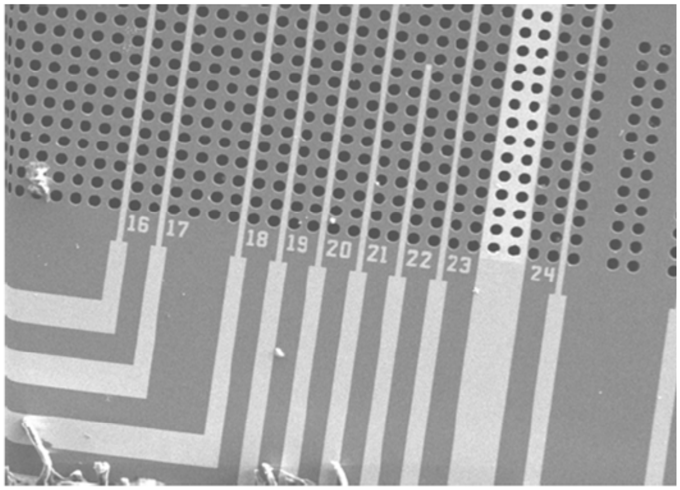

Figure 2. The surface is labeled with numbers and it shows how we deposited the substrate with a developer material.

energy (Bahari et al., 2006; Bartels et al., 2007; Buchs and Muller, 1991; Carpick and Salmeron, 1997; Chiu et al., 2007).

EXPERIMENTAL DETAILS

The microelectrode array device, also called the chip, has been designed to be used for brain slices. The chip differs from most other microelectrode arrays. As we can see in Figures 1 and 2, the substrate is perforated and the electrodes are deposited on the patterned surface and exposed to a developer solution. This technique is used to enhance etching of the material.

In a semiconductor chip fabrication, photo resistive material is used as an overlay, which will protect substrate areas (typically metal) that must remain on the chip after other unprotected substrate areas are etched off. The shape and size of the photo-resistive material, at the sub micron level, is therefore largely responsible for the shape and quality of the protected substrate. While critical dimension scanning electron microscopy (SEM) is used to determine this shape, SEM is suitable in making fine resolution pictures from the surface of IC's, chips and other microstructures. With backscattered electron detectors, we can carry out measurements on surface morphology and material distribution separately. However, sample dimensions have to be less than 30 x 30 mm.

Now, we looked at a piece of chip that was cut off from a 5 x 5 cm semiconductor chip as previously addressed and shown in Figure 2. It should be noted that we looked at it with the secondary electron detector and backscattered electron detector, which resulted in the image shown on Figure 1.

There are indications of different elements, because there are bright and dark regions. Conversely, negative regions exhibit a higher SE yield because secondary electron is repelled and has a greater probability of reaching the detector. Although most IC's (such as microprocessors) operate at a frequency that is too high for their voltage cycles to be observed directly, this sequence can be slowed down and viewed in a TV-rate SEM image by use of a stroboscopic technique . We can see that the resolution of this picture is not good enough. This is because there is a thin over layer of silicon dioxide on the surface of the chip. Even though the resolution is not at the same level, we still see indications of the sample's topography.

The brain slice can be placed on the perforated substrate of the chip that is supplied with nutrients and gas from both above and below and the brain slice will therefore have a longer lifetime. The electrode can be used as a shape for larger contact area and stronger interaction between electrode and tissue. Thus, the electrodes can penetrate the brain slice without damaging the cells too much (Bahari et al., 2006; Bartels et al., 2007; Buchs and Muller, 1991; Carpick and Salmeron, 1997; Chiu et al., 2007), if, of course, we are able to clean the chip and porosity. For this purpose, the chip is mounted in a holder and introduced in the UHV after the sample and holder are rinsed with ethanol in an ultra sonic bath. All further cleaning was done inside the UHV chamber by heating the sample and/or passing a direct current through it, initially to 1100 0 C. The sample is now introduced in the electron microscope chamber for getting SE and BSE (Figures 1 and 2).

The yield of secondary electrons from the electrode tips and the edge of the holes is large because of topographical reasons and these appear bright on the conductors, which therefore becomes rather bright on the images. Of course, a conductive channel not capable of conducting all electrons necessary to avoid charge-up of the surface and fewer secondary electrons generated in the deeper parts of the interaction volume are able to leave the chip through the conductive channel than at the higher beam energies.

RESULTS

By analyzing these images and X-ray maps, the range of the primary electrons and the effects of the electron beam on the chip can be evaluated and the possibility to use the SEM as an instrument for quality check of the chip can be estimated.

These figures show us the secondary electron image of a chip (the surface layers have been removed by low angle polishing) and the backscattered electron image of the same chip. The sum of the signals from different detectors is sensitive to the composition of the surface, whereas the differences of signals from two separate detectors are sensitive to the morphology of the surface, while the composition contrast is depressed.

Conclusion

The obtained results indicate that the films of nano-chip surface are in some degree of inhomogeneity. This quantification of nano-chip is complicated by the presence of some elements such as Si, which results to less accuracy than the above results. However, it can be used to estimate depth resolution. Furthermore, a conductive channel in the chip makes it possible for electrons entering the device as well as electrons generated in the material of the device, to leave the specimen and essentially, no charge–up of the surface is observed ((Fromherz and Leffet, 1996; Morales et al., 2002; Seiple and Pelz, 1994;Vincek et al., 2003).

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