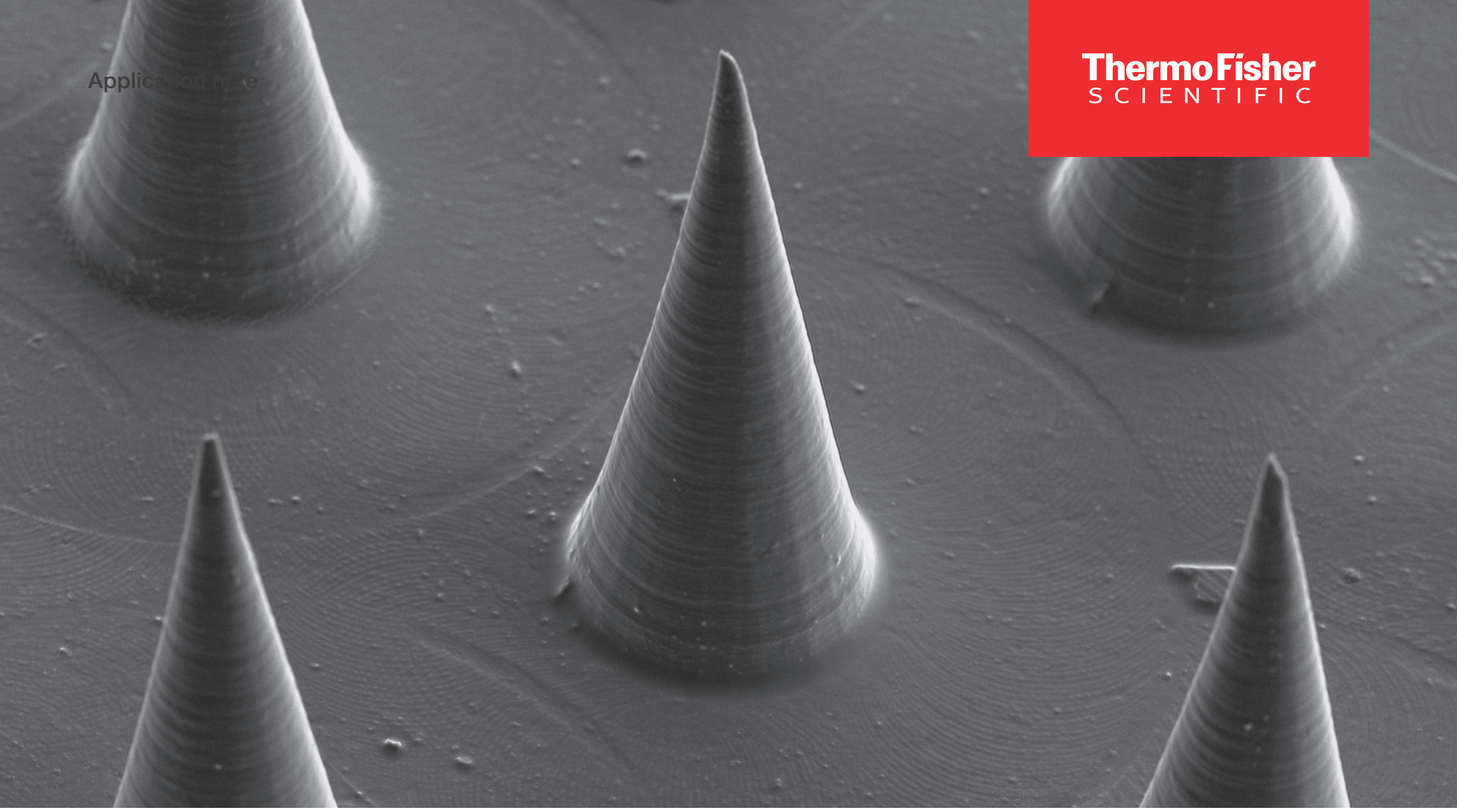
Application note



Scanning electron microscopy in microneedle patch testing

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Microneedle patches have gained significant attention for their excellent ability to deliver medications almost painlessly through the outer layer of skin. These microneedles can be made from various materials including metals, glass, polymers, and hydrogels; their design and shape are diverse to meet different drug delivery needs. For instance, “poke-and-dissolve” microneedles, which are usually made by casting or micro-molding of polymers and simple sugars, encapsulate the drug within the microneedles and release it through mechanical erosion after penetrating the skin. The end result is an efficient delivery system that produces no biohazardous waste.

Microneedle manufacturing

The manufacturing of microneedles involves precise control over their geometric shape, base and tip diameter, length, and spacing. These factors are crucial for the penetrative ability of the microneedles. During production, changes in the viscosity of the raw materials, wear of the molds, and control of the drying temperature can all affect the final needle shape. Therefore, strict quality control and inspection are key to ensuring the effectiveness and safety of the final patch.

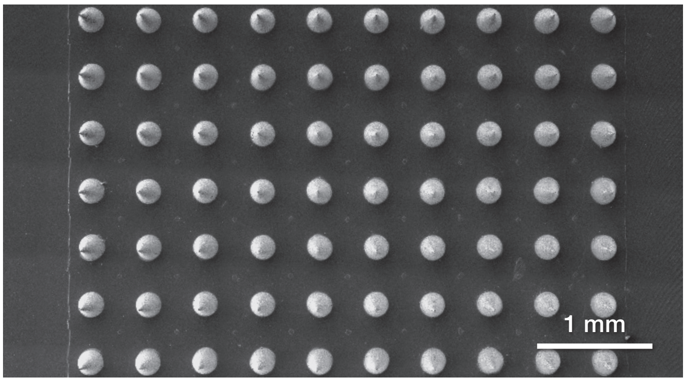


Figure 1. SEM image of a microneedle patch.

Application of SEM in microneedle testing

Scanning electron microscopy (SEM) allows for high-resolution imaging of microneedles; energy-dispersive X-ray spectroscopy (EDS), performed in the SEM, offers additional chemical insights. With the automatic image mapping (AIM) function of the Thermo Scientific™ Phenom™ XL G2 Desktop SEM, the entire microneedle patch can be quickly surveyed (Figure 1). This can be used to check the overall arrangement and shape of the microneedles; details of each individual needle can also be obtained with further magnification. Figure 2 shows such a close-up side view of the needles after tilting, providing crucial information on the size and tips of the microneedles. EDS analysis was also used to quickly detect the drug contents of the microneedles (Figure 3). The needles are shown to contain cerium, which is a known component of the therapeutic used in this experiment, indicating successful drug loading.

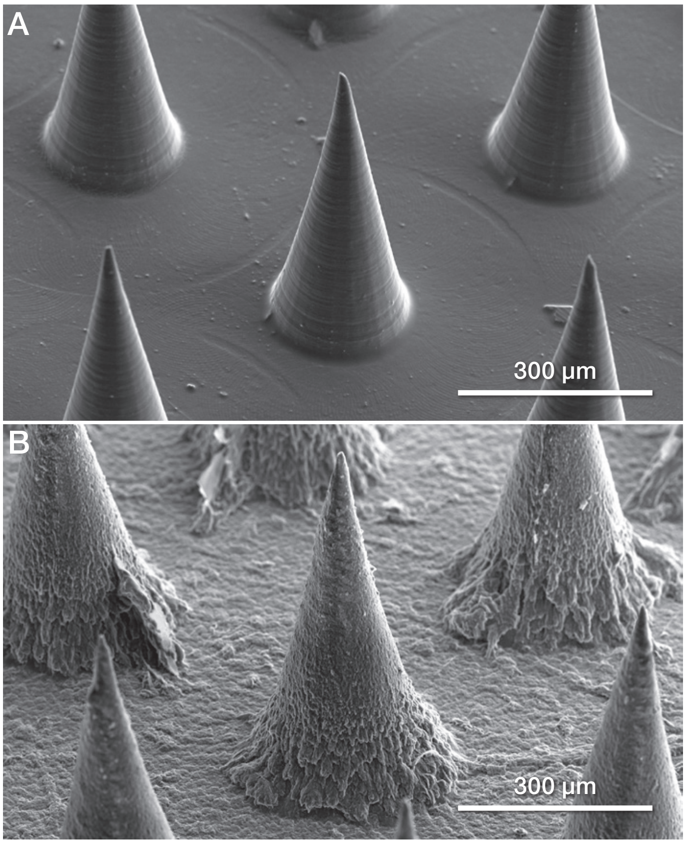
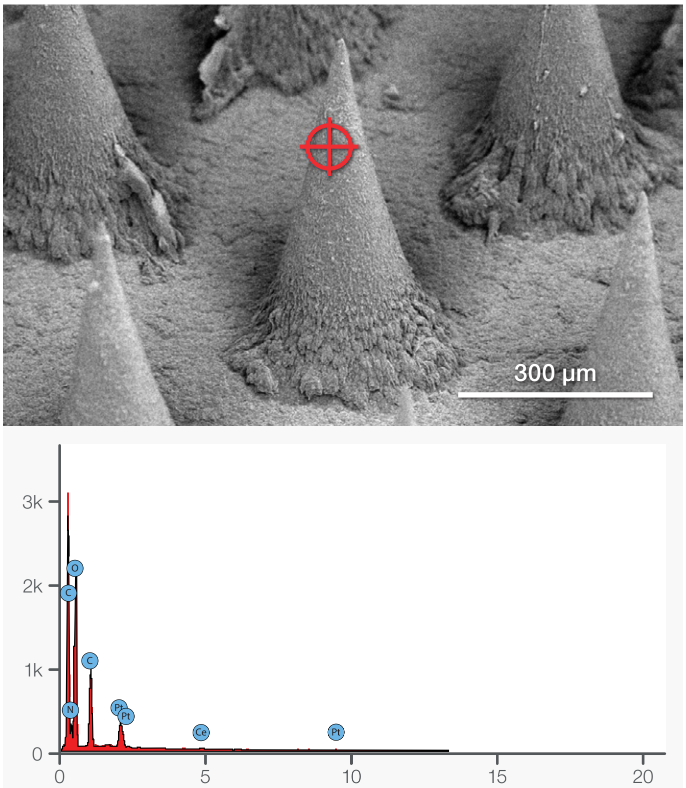


Figure 2. SEM images of tilted microneedles. a) Drug-free microneedles. b) Drug-filled microneedles.



Element	Atomic conc. (%)	Weight conc. (%)
Carbon (C)	44.867	34.100
Nitrogen (N)	7.670	6.800
Oxygen (O)	40.098	40.600
Sodium (Na)	6.596	9.600
Cerium (Ce)	0.169	1.500
Platinum (Pt)	0.599	7.400

Figure 3. EDS elemental analysis of drug-loaded microneedles.

Practical application testing of microneedles

Application testing on mouse models is an important method for evaluating microneedle patch effectiveness. Figure 4a shows the microneedle patch after it had been applied to mouse skin; the tips of the needles have dissolved, indicating successful drug release during the experiment. Conversely, Figure 4b shows a set of microneedle tips that have bent under stress, indicating that they were unable to successfully penetrate the skin and deliver the drug. These observations offer avenues of investigation to further optimize the microneedle design.

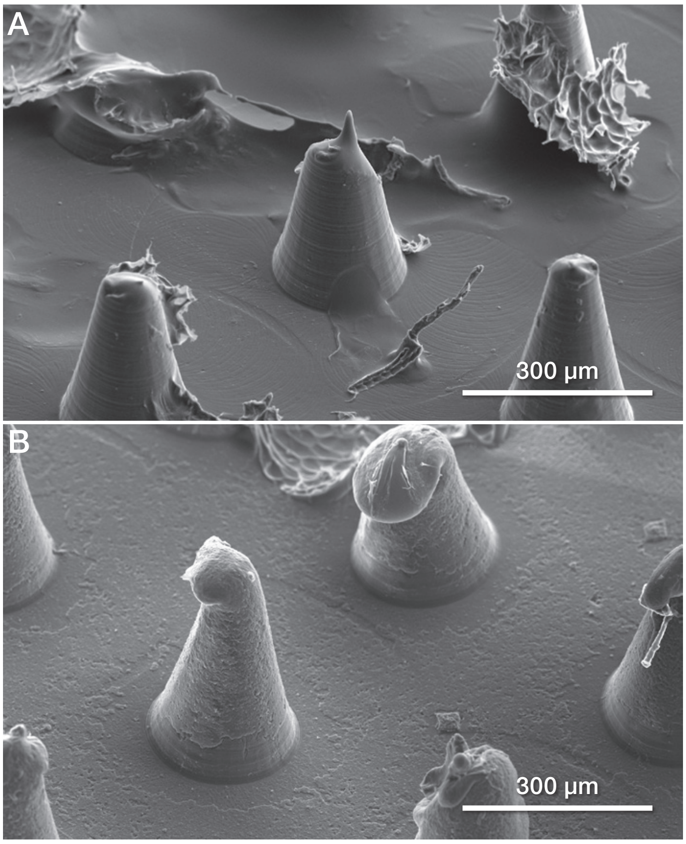


Figure 4. SEM images of microneedles after application testing on mice. a) Successful dissolution of the microneedles following skin penetration. b) Microneedle tips bent under stress.

Conclusions

In the development and quality assurance of microneedle patches, SEM provides indispensable observation of needle structure at high resolution, and can be used to check their performance in drug loading and skin penetration. This information can be used to enhance the performance and reliability of microneedle patches.

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