Imaging of Bioengineering Surfaces with the Helium Ion Microscope

L. Scipioni[1], C. Huynh[1], I. Smith[2],

1. Carl Zeiss SMT, Inc., 1 Corporation Way, Peabody, MA 01960, USA.
2. University of Michigan School of Dentistry, 1105 N University, Ann Arbor, MI 48109, USA

l.scipioni@smt.zeiss.com
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Construction of artificial scaffoldings to support bone growth in implants is a current research topic [1]. We did an imaging study of the very early stages of scaffold growth. The system studied consisted of a thin film of the biodegradable polymer poly(L-lactide) (PLLA), which had been immersed in simulated body fluid (SBF) for short amounts of time. During these incubation periods (1 hour and 3 hour trials were made), hydroxyapatite crystals began to form on the PLLA surface. The goal was to study the early phases of this growth.

The study of such a system in the scanning electron microscope is faced with several challenges. The problems encountered can be seen in Figure 1. First, these samples are highly charging, so it can be quite difficult to obtain charge balance. The alternative is to provide a conductive coating on the samples. However, this distorts the important surface information being sought. Second, the PLLA is sensitive to electron beam irradiation, thus it decomposes with even a typical imaging dose. This makes high resolution imaging impossible. Third, the surface structure of these polymers are difficult to see because of beam penetration effects – greater surface sensitivity is desirable.

The helium ion microscope (HIM) is a new and radical technology for high resolution imaging [2]. It utilizes a high brightness ion source and electrostatic optics that enable image resolution down to 0.25 nm. Due to the fact that the secondary electrons (SE) produced by an incoming helium ion beam are very low in energy, the escape depth for these SE is just a couple of nanometers [3], giving an extremely high surface sensitivity. And there is no need to go to low beam energy to have this surface specificity in the images: both surface detail and maximum resolution are available simultaneously. For insulating samples, the positive polarity of the charging can be neutralized with a low energy electron flood gun, which is on-board the tool. An additional benefit for polymer imaging is that helium ions scatter mainly from the nuclei of the target and do not interact with the chemical bonds directly – this makes it possible to image materials that are sensitive to electron beams. Figure 2 shows an HIM image from the same experimental set as Figure 1. The artifacts that plagued the SEM imaging are avoided, and it is possible to see a great amount of surface detail on the sample. We will introduce some of the fundamentals of HIM and go into further depth on the imaging of bioengineering materials.

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1. R. Zhang and P. Ma, Macromol. Biosci. **4**, (2004), p100.
2. J. Morgan et al., Microscopy Today, **14(4)** (2006), p24.
3. D. Joy et al., Micrsoc. Microanal., **12(2)** (2006), 1146CD.

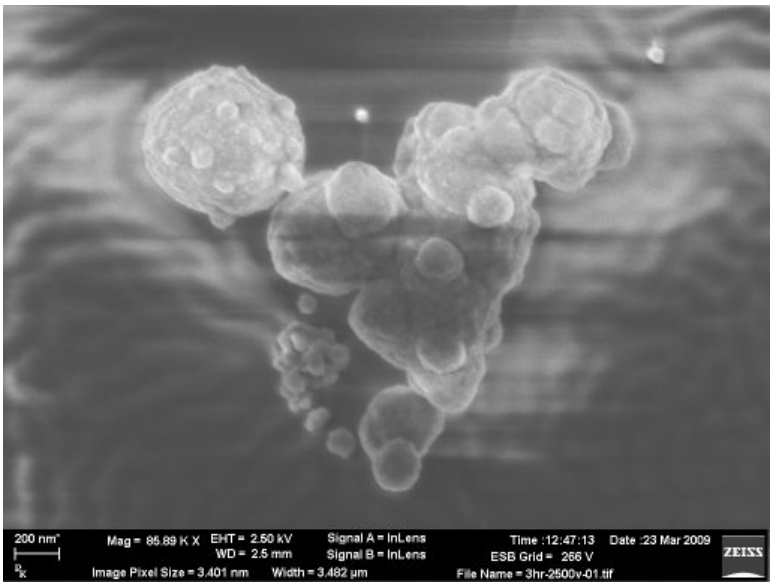

Figure 1. SEM image of PLLA polymer film with hydroxyapatite crystals. Incubation time in SBF was 3 hours.

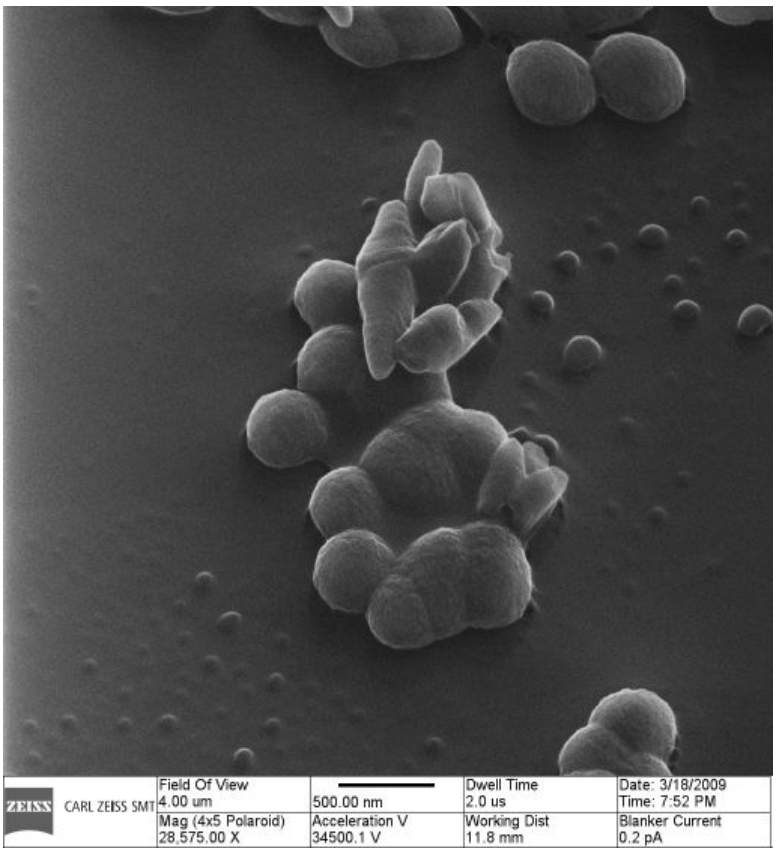

Figure 2. Helium ion microscope image of PLLA polymer film with hydroxyapatite crystals. Incubation time in SBF was 1 hour.

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