

3-D characterization of polymeric biomaterials and model drug delivery systems with cluster secondary ion mass spectrometry

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Secondary Ion Mass Spectrometry (SIMS) has proven to be a useful tool in the analysis of biomaterials and drug delivery systems. With SIMS, the distribution of components in biomaterials systems can potentially be determined with a high degree of spatial resolution ($<1 \mu\text{m}$) and sensitivity (as low as ppm ($\mu\text{g} / \text{g}$)) when compared to other analytical methods such as Raman and IR spectroscopies [1]. Cluster primary ion sources (such as SF_5^+ and C_{60}^+) have already generated considerable interest for organic SIMS analysis, where they have resulted in significant improvements (up to 1000 fold) in characteristic molecular secondary ion yields and in some cases have resulted in decreased beam-induced damage [2,3,4]. This decreased beam-induced damage coupled with an increased sputter rate has led to the ability to depth profile through some organic and polymeric materials without the characteristic rapid signal decay observed with monatomic primary ion sources [2,4]. Hence, cluster SIMS can now be used to elucidate the 3-dimensional structure in drug delivery systems.

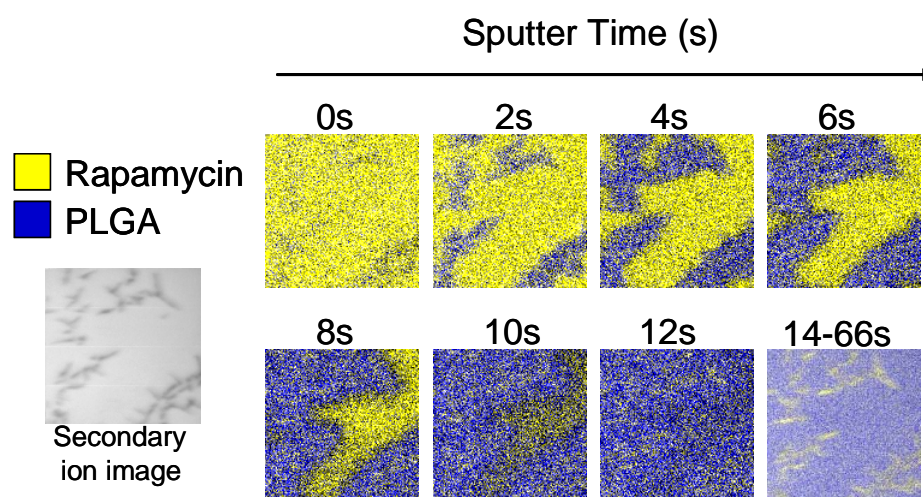


Figure 2. Overlay of Secondary ion images ($200 \mu\text{m} \times 200 \mu\text{m}$) acquired as a function of increasing sputter time in a PLGA film containing 25% w/w Rapamycin. Blue represents $m/z = 99$ (PLGA) and yellow represents $m/z = 84$ (Rapamycin). The sputter time is directly related to the depth into the sample ($\sim 1 \text{ nm} / \text{s}$ sputter rate)

An example of this is illustrated in Figure 1 which shows the resulting secondary ion image overlays as a function of sputter time (depth) in coupons obtained from Medtronic, a manufacturer of drug eluting stents (DES). These particular coupons were prepared by coating steel substrates with poly(lactic-co-glycolic acid) (PLGA) containing 25% w/w rapamycin (~5-6 μm). The secondary ion image overlays are of $m/z = 99$ (fragment characteristic of PLGA) and $m/z = 84$ (fragment characteristic of Rapamycin) in a PLGA film containing 25% rapamycin. These images give detailed information on the heterogeneity in the surface and near surface region in these systems.

References

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