

The physical limits of laser desorption[†]

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The ability to analyze nanoscale samples is a crucial seed for the nanoscience revolution. It is important, therefore, to examine the physical limits of the laser desorption process and our ability to measure this flux. A new generation of mass analyzers can now efficiently detect and identify samples with only a handful of atoms or molecules.(1-3) Questions of lateral and depth resolution remain. Laterally samples have been analyzed with submicron dimensions.(3-6) The achievable depth resolution has received only cursory examination to date.(7, 8) We employed a liquid gallium/indium eutectic alloy, which we previously used for sputtering depth of origin studies(9) to evaluate the achievable depth resolution. Indium strongly segregates to the surface; naturally labeling the first atomic layer. The desorption yields of both gallium and indium neutral atoms show the expected linear behavior but with a clear break in slope at low fluence. That the yield is linear in $1/E$ both at high and low fluence indicates that the desorption mechanism is predominantly thermal in both cases, however there may be an additional mechanism enhancing the yield at low fluence (such as low-level oxide impurity seeds) Our results also show that even at the lowest measurable fluence, 20-30% of the sputtered neutral flux originates from below the top monolayer (**Figure 1**).

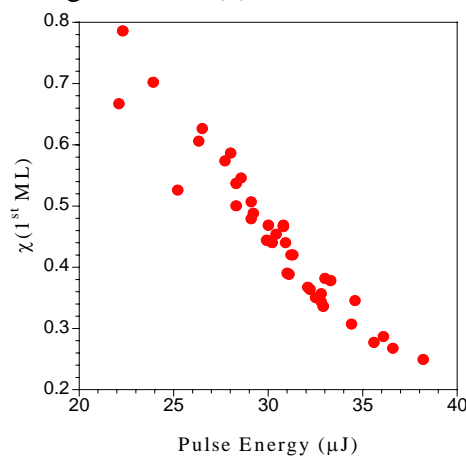


Figure 1 Fraction of ejected neutral atoms originating in the top monolayer as a function of laser

1. B. O. Keller, L. Li, *Journal of the American Society for Mass Spectrometry* **12**, 1055 (2001).
2. B. V. King *et al.*, *Nuclear Instruments & Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms* **190**, 203 (2002).
3. I. V. Veryovkin, W. F. Calaway, J. F. Moore, M. J. Pellin, D. S. Burnett, *Nuclear Instruments & Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms* **219-220**, 473 (2004).
4. A. F. M. Altelaar, J. Van Minnen, C. R. Jimenez, R. M. A. Heeren, S. R. Piersma, *Analytical Chemistry* **77**, 735 (2005).
5. L. A. McDonnell *et al.*, *Journal of Mass Spectrometry* **40**, 160 (2005).
6. J. Maul *et al.*, *Nuclear Instruments & Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms* **226**, 644 (2004).
7. A. Wucher, S. Sun, C. Szakal, N. Winograd, *Analytical Chemistry* **76**, 7234 (Dec 15, 2004).
8. O. L. Bourne, D. A. Hart, D. M. Rayner, P. A. Hackett, *Applied Physics A: Solids and Surfaces* **A59**, 295 (1994).
9. T. B. Lill, W. F. Callaway, M. J. Pellin, D. M. Gruen, *Physical Review Letters* **73**, 1719 (1994).

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