# Acceleration and Characterization of Protons and Ions from Nanometer-Scale Thin Polymer Foil

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Interaction of ultra-intense laser with ultrathin foil targets has attracted great interests for the achievements of multi-hundred MeV protons and ions[1], quasi-monoenergetic electron bunches, and bright x-ray beam[2]. In the previous studies, aluminum, Mylar, silicon nitride, and diamond-like carbon have been used as the targets. As a different target material, being novel to the relativistic laser-matter interaction community, we have developed a freestanding, nanometer-scale foil target made of a conjugate polymer material, poly(9,9'-dioctylfluorene-*co*-benzothiadiazole) (F8BT)[3]. The material was spin-coated onto an optically flat substrate to a film thickness of 5–500 nm. The film was floated on water, and then transferred to a special holder having an array of bored holes to provide the freestanding foil target. It has been demonstrated that the target is robust enough to be used for PW laser beam and also efficient for the multi-ten MeV proton acceleration in terms of repetitive single-shot operation, easy fabrication and thickness control, and relatively cheap production cost. The ion acceleration experiments have been systematically performed using our well-established laser-target interaction system[4] which enabled tight focusing of PW laser beam, precise alignment of the target within a few tens of □m, and characterization of the ions. With the application of well-characterized PW laser pulses, the ultrathin foil targets have been proven to be very effective in generating protons and ions with energy per nucleon in the range of several tens of MeV.

[1] A. Henig, S. Steinke, M. Schnürer, T. Sokollik, R. Hörlein, D. Kiefer, D. Jung, J. Schreiber, B. M. Hegelich, X. Q. Yan, J. Meyer-ter-Vehn, T. Tajima, P. V. Nickles, W. Sandner, and D. Habs, "Radiation-pressure acceleration of ion beams driven by circularly polarized laser pulses," Phys. Rev. Lett. 103, 245003 (2009).
[2] D. Kiefer, M. Yeung, T. Dzelzainis, P.S. Foster, S. G. Rykovanov, C. L. S. Lewis, R. S. Marjoribanks, H. Ruhl, D. Habs, J. Schreiber, M. Zepf, and B. Dromey, " Relativistic electron mirrors from nanoscale foils for coherent frequency upshift to the extreme ultraviolet," Nat. Commun. 4, 1763 (2013).
[3] I. W. Choi, I J. Kim, K. H. Pae, K. H. Nam, C.-L. Lee, H. Yun, H. T. Kim, S. K. Lee, T. J. Yu, J. H. Sung, A. S. Pirozhkov, K. Ogura, S. Orimo, H. Daido, and J. Lee, "Simultaneous generation of ions and high-order harmonics from thin conjugated polymer foil irradiated with ultrahigh contrast laser," Appl. Phys. Lett. 99, 181501 (2011).
[4] I. W. Choi, H. T. Kim, N. Hafz, T. J. Yu, J. H. Sung, S. K. Lee, C. M. Kim, I J. Kim, Y.-C. Noh, D.-K. Ko, and J. Lee, "Target diagnostic systems for proton, electron, and x-ray generation experiments based on ultraintense laser-target interactions," J. Korean Phys. Soc. 55, 517 (2009).