Densities of Thin-Film Targets

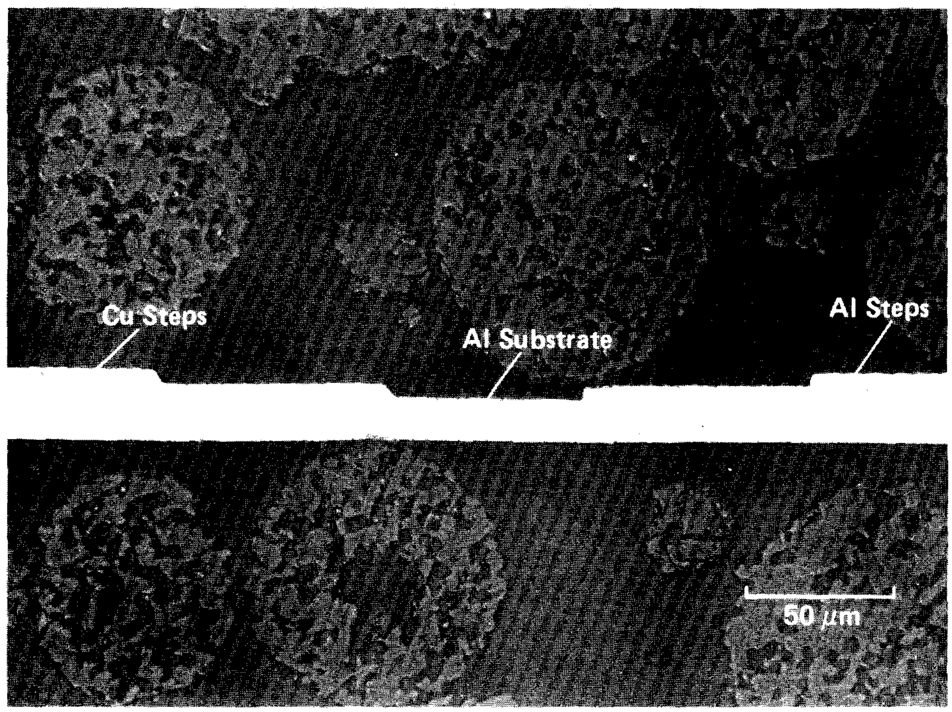
Applications

For several years Los Alamos and Livermore scientists have been using sharply focused high-power, pulsed lasers to produce high-velocity shock waves in thin-film targets. The shock waves create the intense pressures and high temperatures characteristic of the detonation of weapons and other explosives. The purpose of the experiments is to determine equations of state (the relationship among pressure, temperature, and density) for the target materials under these extreme conditions.

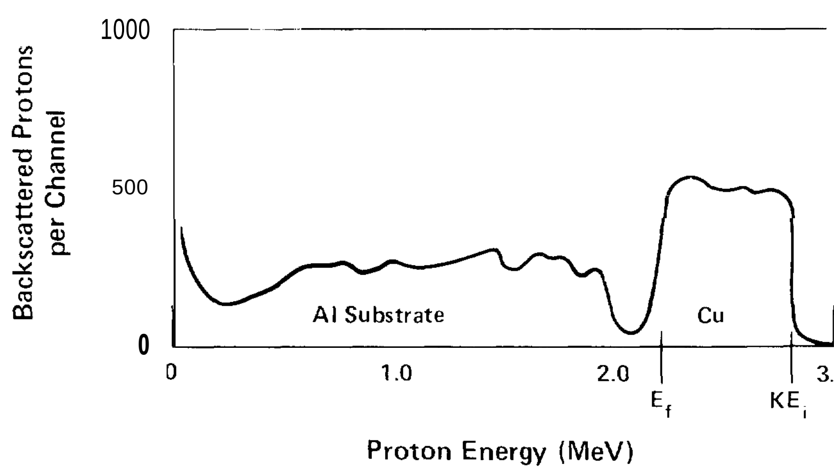
The experiments pose many difficulties, and among them is the need for an accurate measurement of the initial density and uniformity of the targets, which are fabricated by evaporating thin films onto an aluminum substrate, The nuclear microprobe provides a way to measure areal density (mass per unit area) *in situ* and nondestructively. The areal density, which is related to the width of the film's backscattering peak, is then combined with an independent thickness measurement to yield the density with an accuracy of 1 per cent.

Using a few-nanoamperes current of 3-MeV protons focused to a spot 10 micrometers in diameter, we measured the areal density and uniformity of gold, silver, copper, and aluminum targets. [A thin (0.025 micrometer) marker layer of gold between the substrate and the aluminum film permitted a measurement of the aluminum target on the aluminum substrate. The areal density of the aluminum film is then deduced from the observed energy shift of the gold backscattering peak.] In all cases, the areal densities varied from one 10-micrometer-diameter spot to another by less than 1 per cent. The nuclear microprobe is perhaps the only way to obtain such localized information about the areal density. And the superconducting solenoid of the microprobe easily produces the currents and focused beam sizes required to obtain the data in a reasonable time.

This work was performed in conjunction with Lynn R. Veeser of Los Alamos.



Optical micrograph of the cross section of a thin-film target for equation-of-state studies with lasers.



Spectrum of protons backscattered from a target region containing a 5-micrometer-thick copper film on the aluminum substrate. This spectrum is typical of all those from films heavier than the aluminum substrate. The areal density of the copper film is related to $KE_i - E_f$