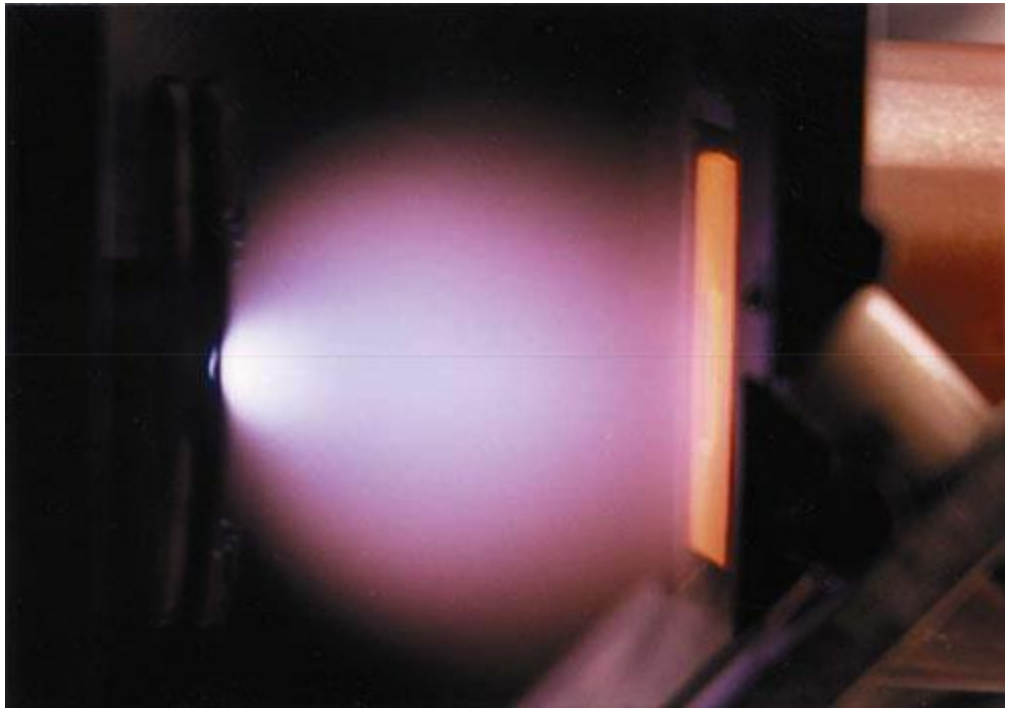
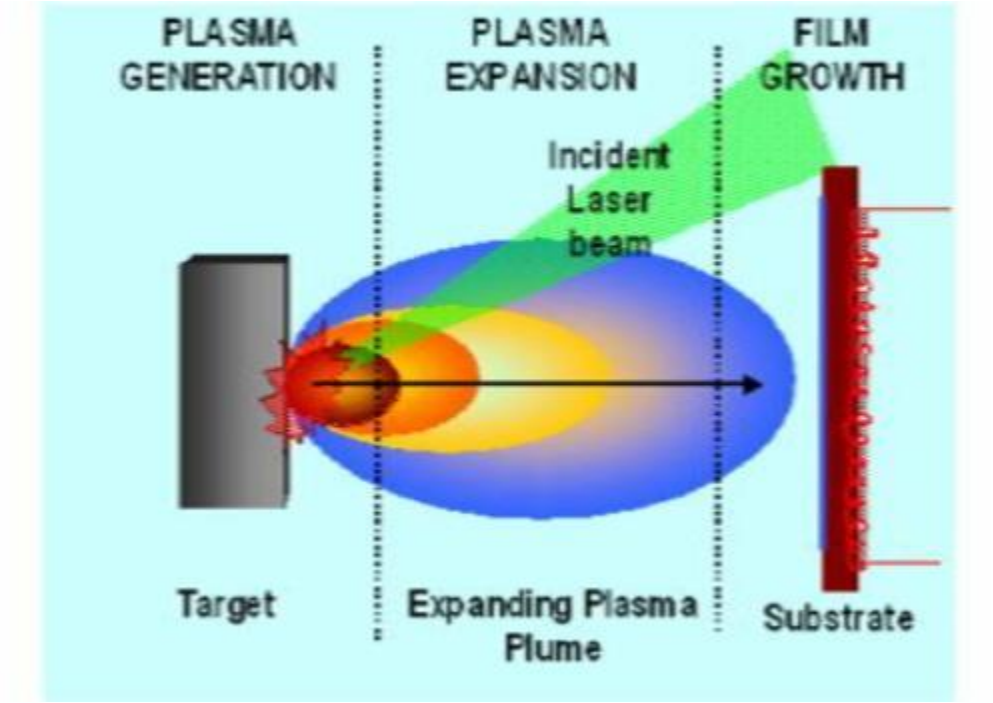
Pulsed Laser Deposition

Douglas B. Chrisey and Graham K. Huber, 1994



Plasma Diagnostics

- Mass Spectroscopy
- Ion Probes
- Optical Spectroscopy
- Laser-Induced Fluorescence
- Photography and Imaging

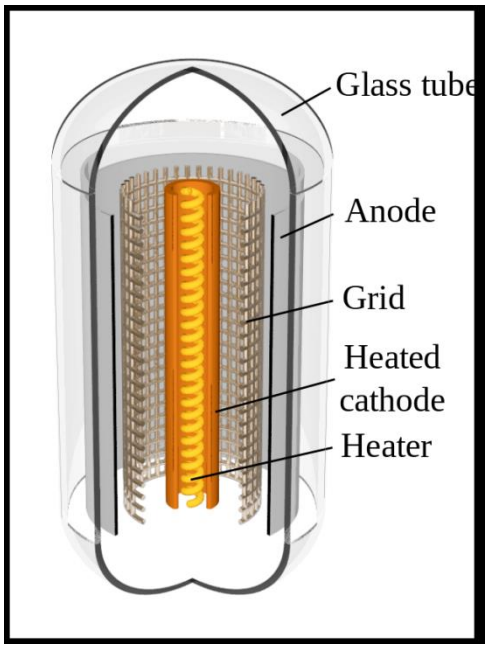


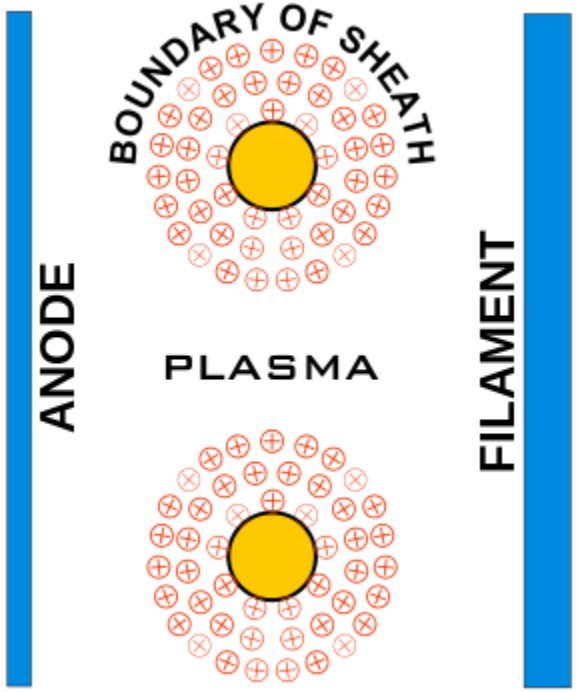
Electrostatic Ion Probes

- Oldest plasma diagnostic method (also called Langmuir probes)
- First developed by Irving Langmuir in the 1920's
- Initially developed to provide electron temperature and density information in "stationary" plasmas (Lamps and vacuum tubes)
- Can be as simple as a grid wire/electrode inserted into plasma
- Voltage applied to probe results in a Debye Sheath forming around the surface

Debye Sheath

- Described by Langmuir and Hull in 1923 and 1929
- Quantitatively described using thermionic gas tubes (vacuum tubes)
- Layer of plasma with greater density of positive ions
- Excess positive charge balanced by negative charge on surface of material
- Voltage applied to grid wires (probe) repels electrons but attracts ions
- Sheath thickness can be several Debye lengths thick in a “stationary” plasma





Langmuir Probe

- Ion probe attracts positively charged ions
- Current pulse collected that records ion flux arriving at probe
- I-V characteristic can be used to derive various properties of the plasma (temperature, density, TOF data)
- In a PLD plasma, the probe potential does not accelerate/decelerate ions or electrons until with $10\mu m$ of probe
- Allows for accurate TOF of electrons and ions

Ion Probes

- In a PLD setup, multi-grid retarding potential probes can be used
- Utilizes a series of wire mesh grids in front of a Faraday cup detector
- Grid 2 repels electrons from plasma
- Grid 3 reduces noise from secondary electrons produced by neutral particles hitting collector or from other sources

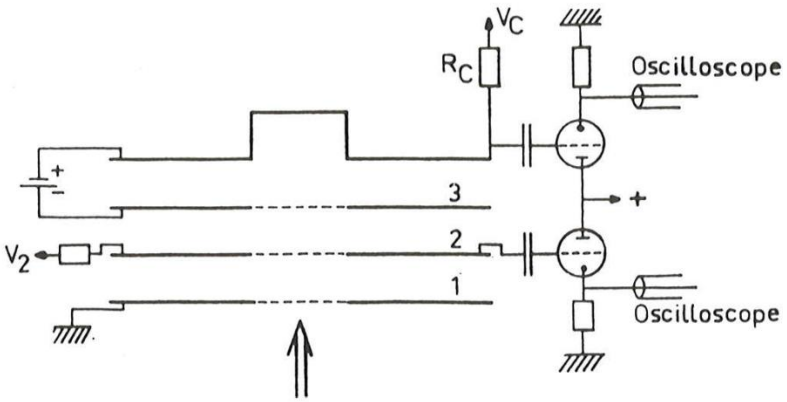


Figure 5.4. Schematic diagram of a multigrid retarding potential probe utilized for fast ($t < 50$ ns) time response analysis of laser-ablated aluminum and copper plumes produced by 30-ns full width at half maximum (FWHM) pulsed ruby-laser pulses. The probe utilizes several grids in front of a Faraday cup detector, maintained at suitable retarding potentials to select electrons and differently charged ions. (Reprinted from W. Demtröder and W. Jantz, *Plasma Physics*, **12**, 691 (1970) with permission.)

Ion Probes

- Collector bias provides energy discrimination of ions
- Repels positive ions with KE<ZeV
- Energy/Charge ratio of ion must be greater than applied voltage to reach the collector
- Can be used to provide Ionization State, KE spectrum, particle flux

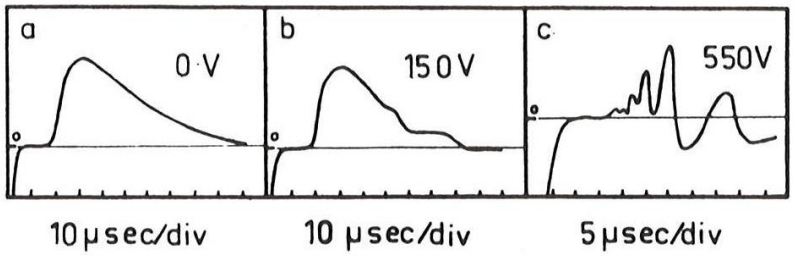


Figure 5.5. Ion-probe collector signals obtained with the ion probe of Figure 5.4 with potentials of (*a*) $V_c = 0$ V (*b*) $V_c = +150$ V, (*c*) $V_c = +550$ V applied to the collector to repel positive copper ions with $KE < ZeV_c$ at a distance of 170 cm from the target. The TOF ion current displays breaks from ions of charge Ze at energy ZeV_c. (Reprinted from W. Demtröder and W. Jantz, *Plasma Physics*, **12**, 691 (1970) with permission.)