of about 20. The accompanying figure shows the difference between the ATI electron energy distribution when linearly (solid curve) and circularly (dashed curve) polarized 10 μm light is used to ionize xenon. This additional factor multiplies the 2000 already mentioned. (Furthermore, if the ion species is not of interest, an additional variable is introduced that can add even greater flexibility!)

Although we have emphasized the implications of MPI for electrons, it is clear that ion motion is frozen on the time scale of an ultrashort laser pulse. The plasma density profile will be determined by the initial gas density profile. Thus, like the electron temperature, the ion density is a parameter under experimental control.

One important implication of these results is the production of plasmas for recombination x-ray lasers. If the plasma electron temperature is less than about 10% of the ionization potential, transient inversions are predicted for hydrogen-like or lithium-like ions. Furthermore, the small scale of plasmas that can be produced by MPI is very favorable for all cooling mechanisms and will facilitate quasi-steady state gain on transitions above the resonance level.

### Real-time enhancement of submicron defects using photorefractives

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We have developed a new approach using photorefractives for real-time inspection of periodic masks or cracks and defects in non-periodic objects. The approach is based on Fourier transform, holographic recording of the object, filtering, and phase-conjugate readout using a photorefractive crystal. These processes are performed simultaneously to allow real-time operation. The object to be inspected (top part of the figure) is placed in the input plane, and the defect-enhanced image in the bottom part appears at the output plane, in a time limited only by the time constant of the photorefractive material. This time constant is material and light intensity dependent and ranges in our experiments from 50 to 250 ms. This method differs from previous approaches in that all operations are carried out in the Fourier domain, no object dependent mask is needed, and real-time operation is achieved without the need for careful alignment of filters and masks.

The technique for performing real-time defect enhancement is based on two observations. First, the Fourier transform of a periodic object is an array of spikes, whereas the Fourier transform of a small defect is a low amplitude, broad signal. The second observation is that the diffraction efficiency of volume phase holograms formed in a photorefractive medium is maximized when the amplitude of the interfering beams is approximately equal, and decreases as the difference in intensity increases. These observations are used in our apparatus, and defects are enhanced by tuning the amplitude of the reference wave to the amplitude of the weak defect signal. This increases the signal strength of the phase conjugated defect signal relative to the periodic background. As a result, a small spot is visible in the output plane at the defect location, and the periodic pattern has been erased from the image, as shown in the lower part of the figure. Defects ranging from 10 to 100 μm² are thus easily located and may be inspected in more detail by subsequent digital or optical processing.

More recently we have extended this approach to include detection of submicron features. As an example, we have detected cracks as small as 0.14 μm in diskheads of magnetic recording devices. The optical signal may be further enhanced by simple digital processing.

### REFERENCES

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The back-lighted Thyratron

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A new optically triggered switch that is useful for high power applications was discovered and is being developed at USC. The optically triggered switch is a back lighted thyatron (BLT), a name that is indicative of its method of operation and the dense glow characteristic of its discharge.

The BLT differs from laser triggered spark gaps in that the laser initiates a glow discharge, closing the switch using unfocused UV incident on the back surface of the cathode. The BLT operates with a discharge that is a uniform, dense glow rather than a spatially inhomogenous arc. The glow mode operation is the result of a super-emissive thermionic cathode. The cathode is self-heated by ion bombardment during the closing phase of the discharge, allowing the switch to operate in a glow mode at very high current, and with very high current rate of rise. The glow operation is similar to that of the pseudospark.

Triggering results from photoemission—typically from a refractory metal electrode—using unfocused light incident on the back of the cathode electrode. Photoelectrons are released from the surface into the cathode back space to begin ionization through "longer path" breakdown—meaning, electrons released from the back surface of the electrode will follow a longer field line, and hence will have a higher probability for collisions. Only a small amount of optical energy is required to initiate the discharge with a delay of 100 nsec and jitter of 1 nsec. The BLT has been triggered using light from various UV lasers, using a flashlamp, with UV from a laser fed through an optical fiber and using the light emitted from a high voltage spark in air.

A UV transmitting fiber, used to bring light into the BLT from a XeCl-laser, produced a small delay and low jitter. The best jitter and delay times were 0.4 ns and 78 ns, respectively, using 4.4 mJ at 308 nm. The BLT is also switched with 2μJ in a 300 ns pulse from a commercial UV flashbulb, although delay and jitter in this case are larger.

Simple and non-destructive optical triggering is a new and useful method for closing a high power glow-mode thyatron-type switch. In a recent application, a three-stage Marx bank incorporating the BLT has been operated. This proof-of-principle Marx bank has been successfully operated at 105 kV with an erection time of ≤ 50 nsec, demonstrating that the low pressure BLT with fiber optic triggering is a candidate for high power devices formerly requiring spark gaps. The BLT thus has potential for high repetition rate operation of what have been heretofore single pulse devices.

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