Pulsed Laser Ablation and Deposition of Polyimide using a Free-Electron Laser

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Previously thin films of thermoplastic polymers including: polyethylene glycol (PEG), polystyrene, and polytetrafluoroethylene (PTFE) have been deposited using resonant infrared pulsed laser deposition (RIR-PLD) [1–3]. Thus, we decided to try a similar technique on thermosetting polymers. Our chosen material is polyimide due to its desirable properties: thermal stability >500°C, chemically inert, and excellent dielectric properties. Polyimide films are synthesized in a 2-step process. First a polymer precursor solution is created by the combination of a dianhydride and a diamine, called an amic acid. The second step requires a thermal cure to cause cyclodehydration. We have successfully transferred the polyamic acid precursor both in air and under vacuum. Currently we are trying to elucidate the central driving force for the ablation; thermal or res

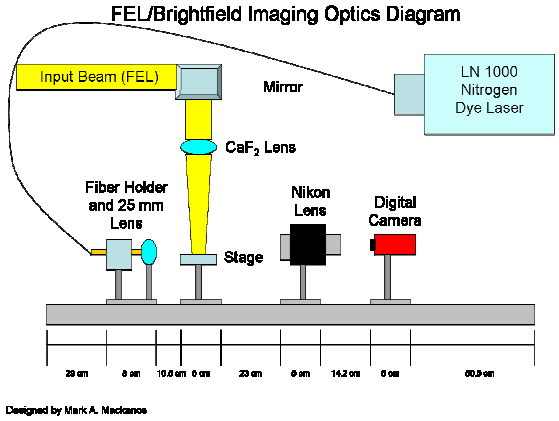

Figure 1

In order to study the ablation mechanism we use bright-field plume imaging, shown below in figure 1. The Free-Electron Laser (FEL) is used to ablate the sample and the N_2 dye laser illuminates the plume so that the digital camera can take a picture. Each picture represents a separate shot from the FEL.

We have been compiling plume image series in which several parameters are varied. The parameters include concentration, wavelength (3.45, 4.8, 5.9, 6.67μm) and fluence amount of energy used to irradiate the surface. The three resonant wavelengths (3.45, 5.9, 6.67μm) all show the occurrence of a shockwave. While, the off-resonance 4.8μm does not; illustrating that the resonant vibrations play an important role in material ejection.

The three resonant wavelengths also show differences, implicating different vibrational states may alter the ablation mechanism.

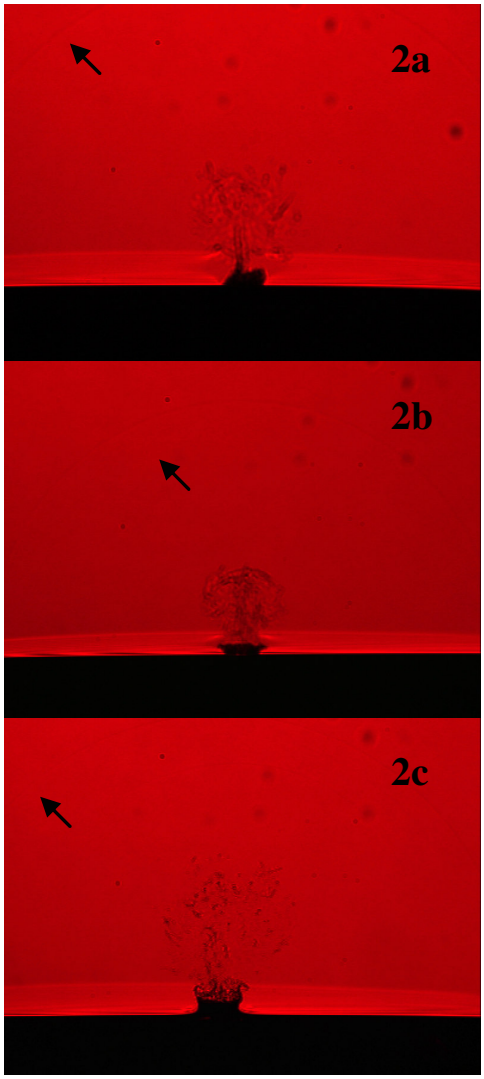

Figure 2: a) 5.9μm b) 3.45μm c) 6.67μm; a-c 15% PAA; 15μs after FEL shot, fluence 2J/cm^2. The arrows indicate the location of the shockwave notice the difference in position in 2b. In 2a and 2b the cloud is mainly vapor while in 2c it is chiefly ejected droplets

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2. D. M. Bubb, M. R. Papantonakis, J. S. Horwitz, et al., Chemical Physics Letters **352**, 135 (2002).
3. M. R. Papantonakis and R. F. Haglund, Applied Physics a-Materials Science & Processing **79**, 1687 (2004).