OPTEC Laser – Optical losses

Mirrors and lenses in the optical path have reflection and transmission losses. For ArF this can be something like 3-4% per optic, and also efficiency degrades with time, until eventually optics need replacing.
The LSV3 optical path from the laser output bezel to the sample has in total 5 mirrors, 1 attenuator optic, 1 beam homogenizer optic and 4 lenses.

The beam has to fill the primary mask motif. Of course, in reality, the beam overfills the primary mask motif. This we can call geometrical transparency, which for a small motif can be very low. This geometrical loss is directly linear with the surface of the primary mask motif (see values below).

For 193nm, ozone formation in air causes losses, which are usually estimated at 11% per meter path, but can be more than that in enclosed spaces if ozone is allowed to accumulate.
On the LSV3 system, the beam path is flushed with dry nitrogen to limit such losses. But in practice, it is impossible to totally close the beam path.

Of the energy present at the laser output bezel, a part is spontaneous emission rather than real stimulated emission, and has very high divergence. Several percent of the beam energy measured by the laser energy monitor is lost in this way.
Also, the energy indicated by the laser energy monitor is a guide. Indeed, it does happen that in time, airborne hydrocarbons are 'cracked' by the UV and form a thin graphite layer on the optics, which takes a sample of the beam to monitor the energy. The reflectivity of that sampler plate is nominally 5% (back face is AR coated), so 95% of the beam transmitted. With the graphite, the reflectivity of the upstream face can increase so less energy is transmitted. For this reason, it is important to regularly measure the real energy at laser output using an energy meter, to perform mirrors cleaning and/or replacement when needed.

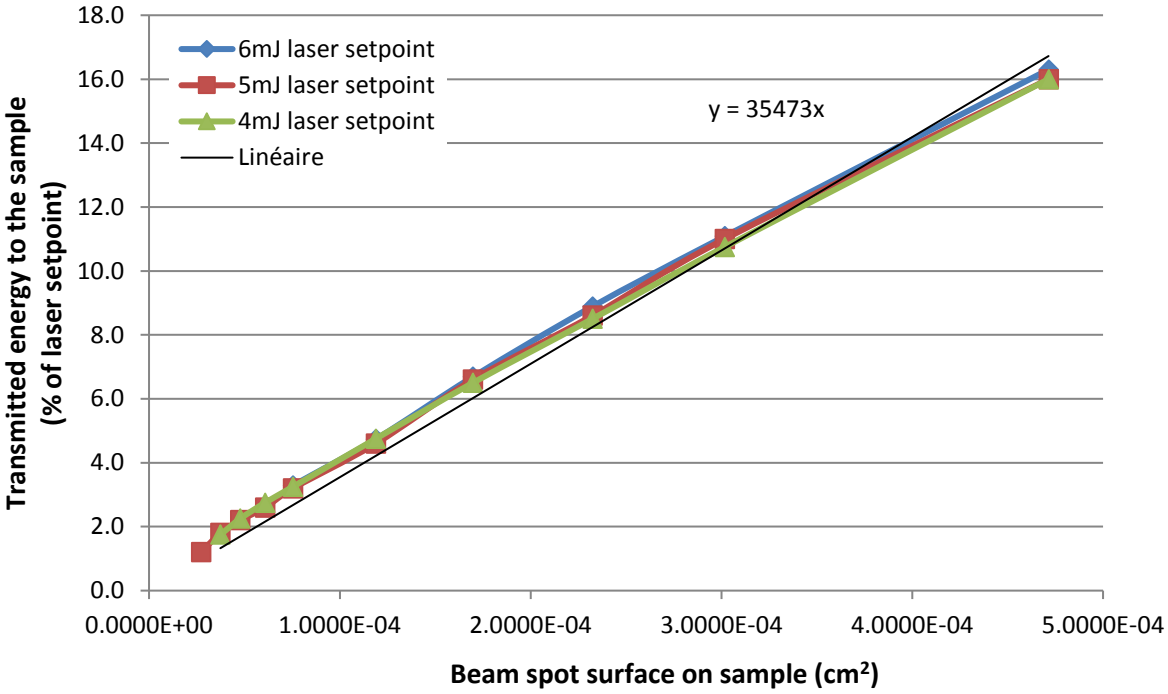
Transmitted energy (%) to the sample for both demagnifications

Laser output setpoint 5mJ – no attenuation

Demag. lens 10X			Demag. lens 16X		
Mask diam. after demag (µm)	**Energy measured on sample (mJ)**	**%trans.**	**Mask diam. after demag (µm)**	**Energy measured on sample (mJ)**	**%trans.**
245	0.8	16	155	0.75	15
196	0.55	11	124	0.51	10.2
172	0.43	8.6	108	0.4	8
147	0.33	6.6	93	0.3	6
123	0.23	4.6	77	0.22	4.4
98	0.16	3.2	62	0.14	2.8
88	0.13	2.6	56	0.12	2.4
78	0.11	2.2	50	0.1	2
69	0.09	1.8	43	0.08	1.6
59	0.06	1.2	37	0.06	1.2

Transmitted energy Vs beam spot surface

(for 10X demag.)



Demag. lens 10X

Mask diam. after demag (µm)	Beam spot surface on sample (cm^2)
245	4.7144E-04
196	3.0172E-04
172	2.3235E-04
147	1.6972E-04
123	1.1882E-04
98	7.5430E-05
88	6.0821E-05
78	4.7784E-05
69	3.7393E-05
59	2.7340E-05
49	1.8857E-05