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Survey of Laser Markets Relevant to Inertial Fusion Energy Drivers

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Auspices Statement

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Description

Development of a new technology for commercial application can be significantly accelerated by leveraging related technologies used in other markets. Synergies across multiple application domains attract research and development (R&D) talent—widening the innovation pipeline—and increases the market demand in common components and subsystems to provide performance improvements and cost reductions. For these reasons, driver development plans for inertial fusion energy (IFE) should consider the non-fusion technology base that can be leveraged for application to IFE.

At this time, two laser driver technologies are being proposed for IFE: solid-state lasers (SSLs) and KrF gas (excimer) lasers. This document provides a brief survey of organizations actively engaged in these technologies. This is intended to facilitate comparison of the opportunities for leveraging the larger technical community for IFE laser driver development. We have included tables that summarize the commercial organizations selling solid-state and KrF lasers, and a brief summary of organizations actively engaged in R&D on these technologies.

Current Status

The high brightness, coherence and power of lasers have made their application ubiquitous across many areas of industrial and domestic technology. Applications include telecommunications, optical storage, printing, computer I/O devices, recording, laser pointers, laser displays, hair removal, laser surgery, LIDAR, interferometry, precision cutting, welding, milling, peening, marking, laser guide stars, defense applications, and the generation of short pulse gamma rays, ions, protons, electrons, and neutrons. The laser marketplace is reviewed annually by several market research organizations, and is summarized every year in publications such as Laser Focus World.[1] These summaries indicate a total worldwide laser revenues ~ $5 to 6 billion per year, of which ~60% is due to diode lasers which dominate the largest application sector (communications and optical storage, 55%).

As an example, to assess the relative prevalence of SSL and KrF technologies, we consider "materials processing," the second largest market segment (~25%), which includes industrial machining as well as semiconductor lithography. Within this segment, the ratio of SSL to KrF revenues is approximately 3.5:1.[2,3]

Tables I and II list manufacturers of SSL and excimer (KrF-type) lasers. Only lasers with power levels at or above 20 W are included; in the interest of limiting the SSL list to a manageable size, the many lower-power SSL manufacturers (e.g., green laser pointers) have been excluded. The SSL list excludes several defense industry manufacturers (e.g., Boeing, Raytheon) who are known to provide SSLs, but do not publish technical datasheets on their websites.

Well over 100 organizations are pursuing R&D on SSLs, while those pursuing KrF R&D number less than 15. This is further illustrated by the technologies being employed at facilities exploring high-energy density (HED) science using high energy laser facilities. Table 3 shows that 15 of the 18 employ SSLs, and two of the three non-SSL laboratories (VNIIEF and IPP) are moving to solid state for their next generation of facilities. A similarly pronounced situation exists for high-intensity laser systems, as represented by organizations participating in the International Committee on Ultra-High Intensity Lasers (Figure 1). Of the more than 70 organizations involved, fewer than five operate excimer lasers.[4]

Summary and Conclusions

The laser markets are dominated by technologies associated with diode-pumped SSLs. Diode lasers alone account for more than half the market, with solid-state lasers accounting for a majority market share. This is reflected by a much larger supply base for SSLs, and by a much larger R&D community.

These circumstances suggest that IFE drivers based on diode-pumped SSLs will find much greater opportunities for leveraging existing technology and emerging R&D, in order to improve performance and minimize costs.

References

1. Tom Hausken, Strategies Unlimited, a Penwell Company, "Laser Marketplace 2010: How wide is the chasm?" *Laser Focus World* annual review, 2010.
2. "Trumpf expects double-digit sales jump," *i-MicroNews* (October 19, 2010). http://www.i-micronews.com/lectureArticle.asp?id=5645
3. KrF revenues from Ref. 1. CO_2 revenues from Ref. 2. Direct-diode revenues are a small fraction of this market. The remainder is SSL revenues (including fiber lasers).
4. International Committee on Ultra-High Intensity Lasers. www.icuil.org

Table I. Manufacturers of Solid-States Lasers with Power of 20 W or Greater.

Manufacturer	Model	Power (W)	Pulsed (Y/N)
Trumpf	TruDisk16003	16,000	N
	TruPulse	530	Y
IPG	YLS1000	10,000	N
	YLP10	200	Y
U.S. Laser	408-4	2500	N
Powerlase	DPSS	1500, 1000	N (Y)
Adapt Laser Systems	CL 1000	1,000	Y
Rofin	Rofin DQ010	900	Y
JMAR	dual head 1250W arrays	850 (425)	N (Y)
Lee Laser	Series 800	800 (150)	N (Y)
Northrup Grumman	Presencia	400	Y
IB Laser	DiNY	360	Y
Photonics Industries	DM300	300	Y
US laser corp	487	200	N
BeamTech Optronics	Tolar	200	N
Sintec Optronics	ST-DPSS-150	150	N
Quantronix	532-150-M (2w)	150	Y
Thales	Etna	110	Y
CNIlaser.com	HPL-1064-Q	100	Y
Mecco		100	Y
Lumera	Blaze	100	Y
FOBA	LP-100	100	N
neoLase		100	Y
Newport Spectra-Physics	Quanta Ray Pro	50	Y
KM Labs	RedDragon	50	Y
Time-Bandwidth	Fuego	50	Y
Coherent	Avia	45	Y
Quantel	Centurion	40	Y
Oxford Laser	neo Nd:YAG	40	Y
Bright Solutions	Luce	40	N
General Atomics	Everest	38	Y
Continuum	Powerlite DLS	35	Y
Litron	LDY354	30	Y
Schilling	Megalight 110	27	Y
LASAG industrial	SLAB	25	Y
New Wave Research	Pagasus PIV (2w)	20	Y
Amplitude Systemes	Tangerine	20	Y
EKSPLA	Baltic HP	20	Y
Meshtel-Intellite		20	N

Table II. Manufacturers of Excimer Lasers with Power of 20 W or Greater.

Manufacturer	Model	Power (W)	Pulsed (Y/N)
Coherent	LSX-600	540	Y
Cymer	XLR60ix	90	Y
Komatsu/Gigaphoton	GT62A	90	Y
LightMachinery GSI	Pulsemaster	80	Y
GAM laser	X50in	50	Y
Tamarack Scientific		40?	Y
MPB Communications	ASX-750	20	Y

Table III. IFE-scale laser research facilities (defined as those with energy > 1kJ).

Laser Facility	Location	Energy	Laser type
National Ignition Facility (NIF)	LLNL, USA	4MJ IR (1.8MJ 3ω)	Nd:glass
Laser Megajoule (LMJ)	CESTA, France	4MJ IR (1.8MJ 3ω)	Nd:glass
Z-beamlet	SNLA, USA	1-2 kJ	Nd:glass
Omega and Omega EP	LLE Rochester, USA	30 kJ 3ω	Nd:glass
Pharos III	NRL, USA	1.5 kJ	Nd:glass
NIKE	NRL, USA	5 kJ	KrF
Vulcan	RAL, UK	2.5 kJ	Nd:glass
Orion	AWE, UK	6 kJ	Nd:glass
LULI -2000	Ecole Polytechnique, France	2 kJ	Nd:glass
PETAL	CESTA, France	9kJ 3ω	Nd:glass
PHELIX	GSI, Germany	4 kJ	Nd:glass
PALS	IPP, Czech Republic	1.2 kJ	Iodine
Gekko XII and LFEX	ILE Osaka, Japan	30 kJ	Nd:glass
Shenguang-II	SIOM, China	6-8 kJ IR (2 kJ 3ω)	Nd:glass
Shenguang-III	Mianyang, China	200 kJ 3ω	Nd:glass
KLF	KAERI, Korea	1kJ	Nd:glass
ISKRA-5	VNIIEF, Russia	30 kJ	Iodine
LUCH	VNIIEF, Russia	12 kJ	Nd:glass

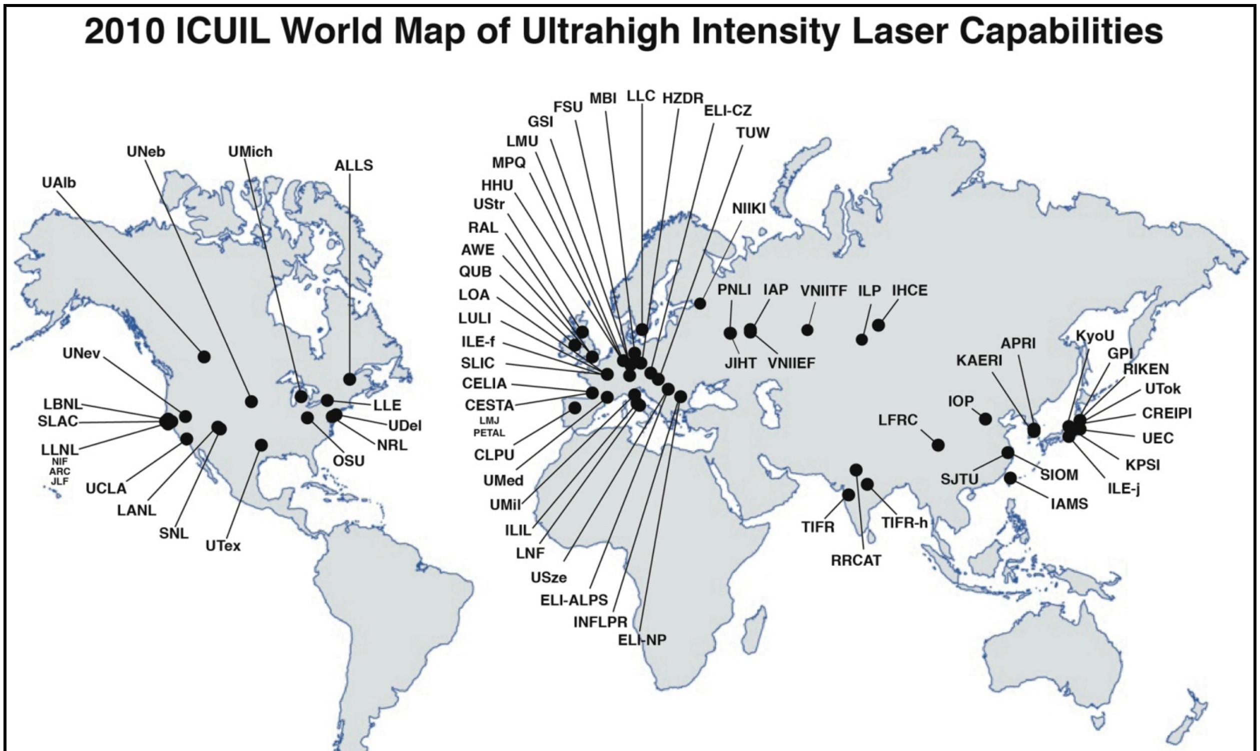

Figure 1. Ultra-high intensity laser organizations of the world.[4]