PJ-2F-1

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CW Operation in Distributed Face Cooling Chip

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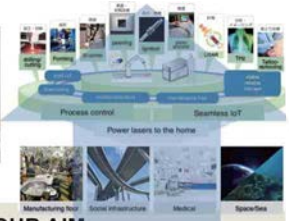
Ultra-compact pulsed power laser

Ubiquitous power laser



OUR AIM

- Tiny-integrated mJ class, sub-ns laser
- Average power over 100 W
- Repetition rate > 10 kHz

Current limitation: heat generation

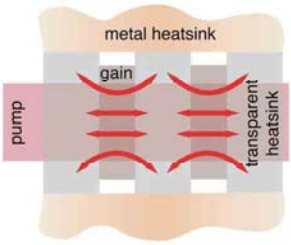
V. Yahia et al., Opt. Express 26, 8609-8618 (2018)

Types of laser configuration

Parameter \ Shape	Rod	Fiber	Thin disk	DFC
				
Maximum extractable power	$P_{cr}=\frac{8\pi R_T L}{\chi}$	$P_{cr}=\frac{8\pi R_T L}{\chi}$	$P_{cr}=\frac{12R_T}{\chi}\left(\frac{A}{t}\right)$	$P_{cr}=\frac{24NR_T}{\chi}\left(\frac{A}{t}\right)$
Power scalability	poor	high	medium	**high**
Gain	medium	high	poor	**high**
Damage threshold	medium	poor	high	**high**

DFC: distributed face cooling, R_T: thermal shock parameter, A: area of gain medium, L: gain medium length, t: gain medium thickness, χ: heating parameter, N: number of chips or disks

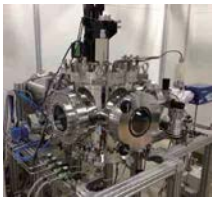
Heat distribution in DFC chip



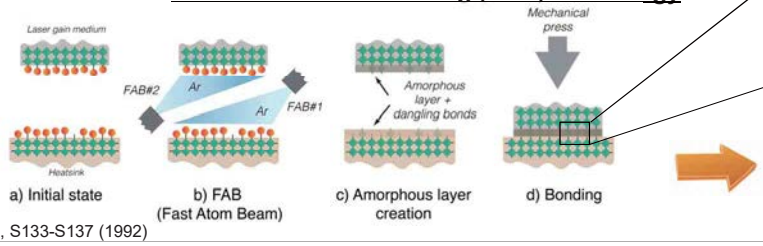
Heatsink: YAG, Sapphire, Diamond
Gain medium: Nd:YAG, Yb:YAG, Cr:YAG etc.

Coated materials are possible too!!

Surface activated bonding (SAB) technology



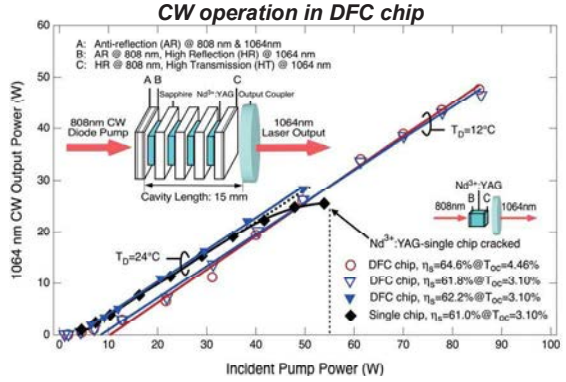
Ultra-high vacuum chamber



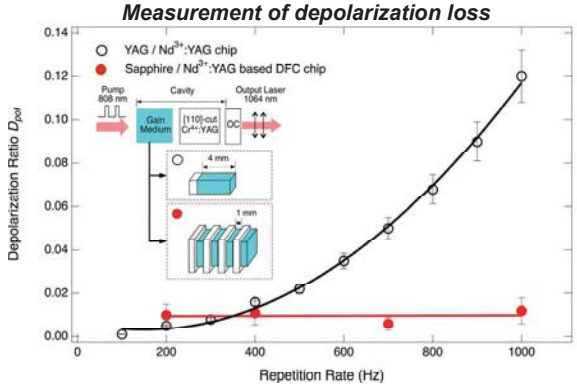
T. Suga et. al, Acta Metall.Mater. 40, S133-S137 (1992)

Experimental results

CW operation in DFC chip



Measurement of depolarization loss



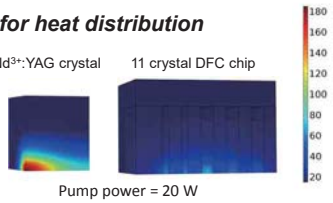
L. Zheng et al., Opt. Mater. Express 7, 3214-3221 (2017)

Optimization of DFC chip. FEA analysis

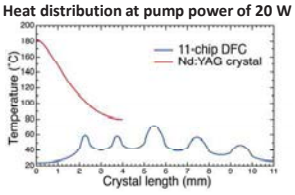
Simulation model for heat distribution

- Top-Hat profile
- Fractional heat load η_h equal to 0.37
- Absorption coefficient is constant
- No saturation of absorption coefficient ($I_{pump} \ll I_{saturation,pump}$)

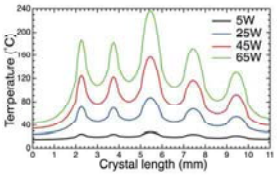
Y. Sato et al. in *IEEE JQE*, vol. 40, pp. 270-280 (2004)



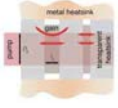
Heat distribution at pump power of 20 W



Heat distribution in DFC chip

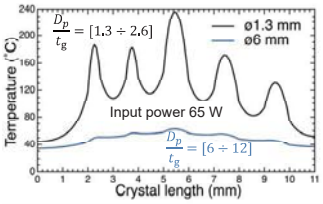


1. Effective heat removing. Pump beam increase



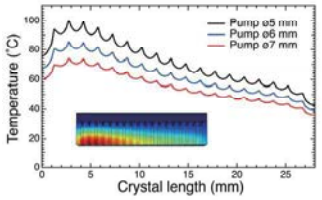
D_p - Pump diameter

t_g - gain chip thickness



2. Heat load reduction. Direct pump by 885 nm

- Nd:YAG thickness 0.5 mm
- Over 300 W of absorbed power
- 37 crystal in total



Distributed face cooling method improves CW output by two times