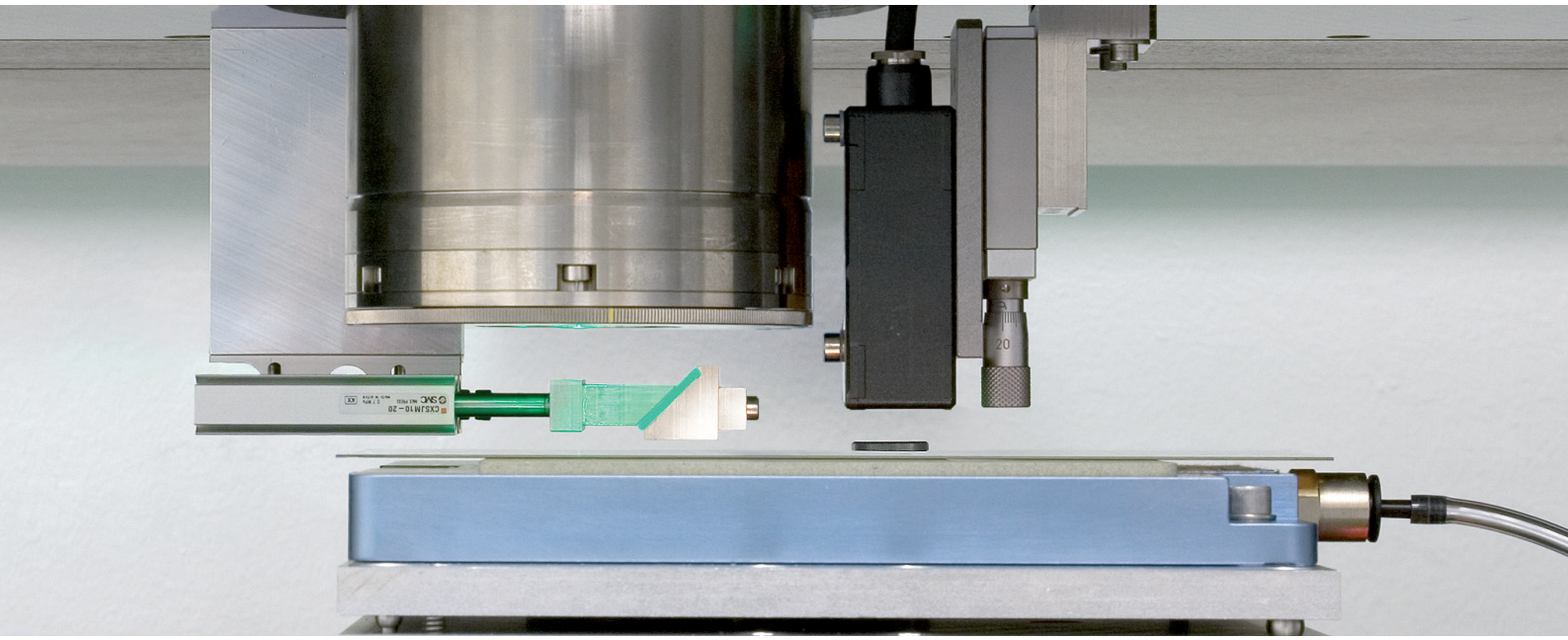
JENOPTIK

LASER OPTICS for Processing of Semiconductors and Thin Films



EAGLE p-lens with shutter mounted on LAVA LASER OPTICS

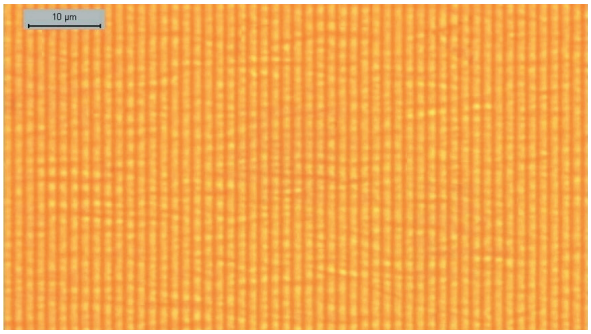
INNOVAVENT® LASER OPTICS

operated by JenLas® **ASAMA Diode Pumped Thin Disk Laser**

LASER OPTICS for Processing of Semiconductors and Thin Films

Flat Panel Diplays

Annealing and crystallization applications are of great importance for the preparation of silicon films in the production of large area electronics and semiconductor devices. LCD and OLED displays take advantage of the thin film transistor performance to switch the display pixel matrix. Driver electronics, memory and CPU circuits can be directly produced on the glass substrate. Thin silicon films are transferred into the liquid phase and controlled solidification results in homogenous crystallization providing high electron/hole mobility.



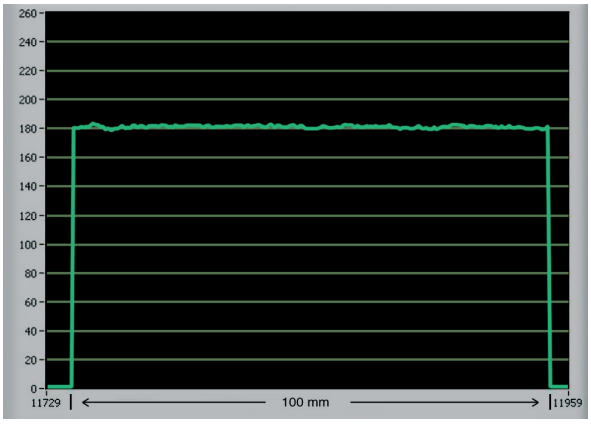
Microscope photo of a 50nm thin silicon film after scanning at 1.5µm pitch (515nm, 50kHz, 900mJ/cm²).

Semiconductor Devices

Another application is dopant activation for CMOS image sensors and IGBT high power transistors. Both benefit from the controlled heating. Buried structures and metal contacts are kept fully intact. Dopant activation at 2µm depth has been demonstrated.

Solar Cells

Laser doping of crystalline solar cells and the crystallization of a-Si thin film cells are emerging applications for pulsed and cw green laser processing. These applications target higher conversion efficiency of next generation solar cells.



Homogenized beam profile at the substrate obtained with LAVA LASER OPTICS operated with the JenLas® ASAMA laser.

Green Laser Wavelength Benefits

Green laser light (515nm, 532nm) is well suited for annealing of thin a-Si films. The dynamic increase of the absorption in a-Si film ($2x10^5 cm^{-1}$) with temperature provides an efficient heating process over 50nm thickness. The absorption length exceeds 1µm in crystalline Si. Pulsed green laser radiation allows to obtain high energy density in exposure intervals from 300ns up to 1,200ns. Applying continuous wave (cw) laser radiation gives access to equivalent pulse duration from ~10µs to the ms range by medium and fast line beam scanning. This time range is well suited for non-melt applications such as solid phase crystallization.

LAVA and VOLCANO LASER OPTICS set up

LAVA and VOLCANO LASER OPTICS

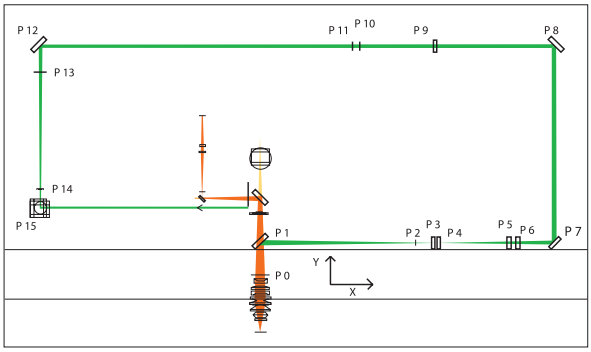
The LAVA optics module forms an intermediate image at a slit position and projects a 10x demagnified Gaussian line focus to the substrate (8mm x 5-10µm, EAGLEplus p-lens). The VOLCANO optics module uses the FALCON NA=0.25 cylinder imaging lens and creates a line up to 200mm in length. A variety of alternative line focus geometries can be customized, delivering an energy density up to 4J/cm^2 with pulsed lasers, respectively 100-400 kW/cm^2 with cw-lasers.

LAVA and VOLCANO LASER OPTICS include monitoring modules, such as focus monitor, beam profiler and power measurement. A p-lens shutter gives full power operation without sample exposure, and an ultra fast AOM shutter optimized for the JenLas® ASAMA pulsed green laser provides single pulse switching up to 100kHz rep.-rate.

Dual and multiple laser head operation by polarization, homogenizer optics and fiber optics coupling opens the way to high throughput applications. Alternatively splitting emitted laser light by refractive and diffractive means allows most efficient use of the high quality laser beam.

JenLas® ASAMA Laser for Pulsed Processing

The JenLas® ASAMA is a second harmonic generation (SHG) q-switched diode-pumped thin disk laser emitting at 515nm. Its Yb:YAG thin disk technology* provides a laser beam which is perfect for homogenization and Gaussian beam focusing with a large depth of focus. The long axis homogeneity benefits from the small temporal coherence length of the Yb:YAG laser emission which suppresses speckles and interference modulations. The unique anamorphic resonator delivers beam quality with M^2=4.5 and M^2>15 in the two orthogonal axes. Homogenization in the large M^2 and focusing in the small M^2 axis makes this a perfect match for Gaussian line focus generation.

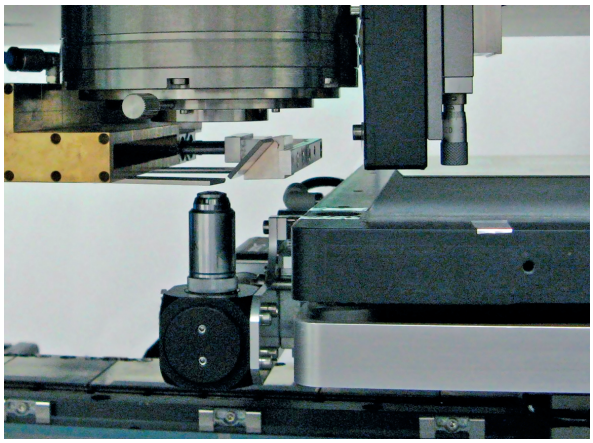


LAVA LASER OPTICS sketch

The JenLas® ASAMA can be operated in a wide rep.-rate range from 10-100 kHz with very small p-p-fluctuation (1σ<1%) and an electronically controlled pulse length (300-600ns at 100 kHz, 300-1,200ns at 10 kHz). The reliability of the JenLas® ASAMA is based on the Longlife Technology of JENOPTIK Diodelaser passively cooled horizontal diode stack technology.

LongLife Technology

* licensed from IFSW Stuttgart



High resolution beam profiler optics below EAGLEplus p-lens to measure Gaussian line beam performance

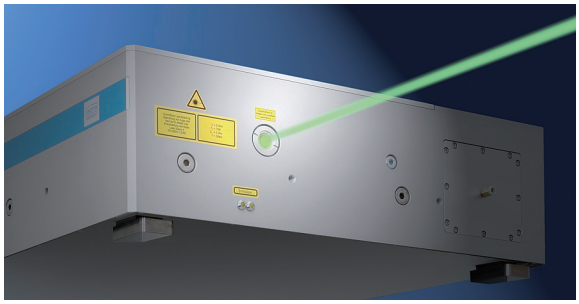
LASER OPTICS for Processing of Semiconductors and Thin Films

cw-Processing and other Wavelengths

LAVA and VOLCANO LASER OPTICS are applied for cw-laser beam forming, too. Not only the green wavelength but also IR line beams are prepared from laser diode and other laser light sources.

The VOLCANO 600CW shapes the 808nm light from a diode laser stack into a homogenous line.

The LAVA CW LASER OPTICS combines green cw-laser radiation from thin disk JenLas® D2.8 laser modules to generate up to 100 kW/cm² in a uniform Gaussian line focus.



JenLas® ASAMA thin disk laser

LASER OPTICS and LASER Products

- Laser optics modules for integration
- IR, visible and UV wavelengths
- Anamorphic illumination optics for Gaussian line focus scanning
- Illumination optics based on diffractive optical elements (DOE)
- Diffraction limited high NA projection lenses
- Homogenizer optics
- JenLas® ASAMA 100-1, 100-2, 80-8

LASER APPLICATIONS:

Application lab service using pulsed and cw lasers for

- Material processing and micromachining
- Semiconductor annealing and dopant activation
- Large area electronics thin film crystallization

Basic Specifications of INNOVAVENT LASER OPTICS

	LAVA 100	LAVA CW	VOLCANO 80/160	VOLCANO 600CW
Line width (FWHM)/µm	5-10	30-100	5-40	100-200
Line length (flat)/mm	4-8	1-8	2-200	1-5
Wavelength/nm	515	532	515	808, 940
Laser power/W	100	48/160	80/160	200-600
energ density/J/cm²	up to 1.5	-	up to 5	-
Power density/kW/cm²	-	up to 100	-	up to 400
Rep.-rate/kHz	100	cw	10	cw
p-p power stability STD=1σ	<1%	<1%	<1%	n.s
Pulse length/ns	300-600	cw	300-1,200	cw
p-lens	EAGLEplus, 10x NA=0.25 FOV=10mm WD>30mm	EAGLEplus, 10x NA=0.25 FOV=10mm WD>30mm	FALCON100/200 10x NA=0.25 WD>30mm	FALCON 10 10x NA=0.25 WD>30mm

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