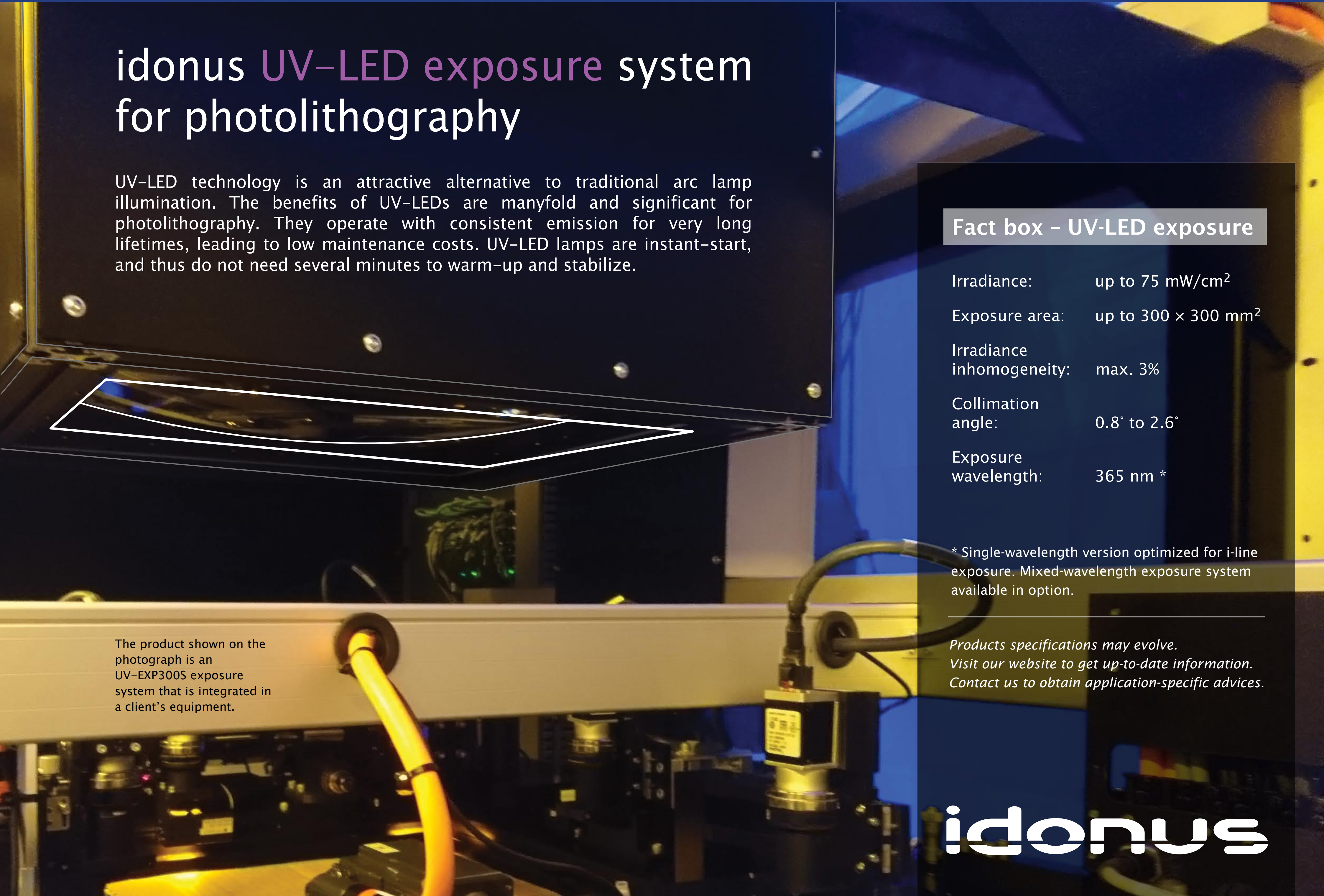
idonus UV-LED exposure system for photolithography

UV-LED technology is an attractive alternative to traditional arc lamp illumination. The benefits of UV-LEDs are manyfold and significant for photolithography. They operate with consistent emission for very long lifetimes, leading to low maintenance costs. UV-LED lamps are instant-start, and thus do not need several minutes to warm-up and stabilize.



The product shown on the photograph is an UV-EXP300S exposure system that is integrated in a client's equipment.

Fact box – UV-LED exposure

Irradiance:	up to 75 mW/cm^2
Exposure area:	up to 300 × 300 mm^2
Irradiance inhomogeneity:	max. 3%
Collimation angle:	0.8° to 2.6°
Exposure wavelength:	365 nm *

* Single-wavelength version optimized for i-line exposure. Mixed-wavelength exposure system available in option.

Products specifications may evolve.
Visit our website to get up-to-date information.
Contact us to obtain application-specific advices.

idonus

UV-LED light source for photolithography exposure

idonus proposes an innovative UV illumination system based on the use of high-power LEDs and high-grade microlens arrays. This product finds application in photoresist exposure and is suitable for a wide variety of substrates. Our complete line of UV illumination products addresses photolithography needs for masks and wafers up to 300 mm wide. Customized solutions can be designed to suit your specific requirements (*e.g.*, retrofit on mask aligners, OEM for your future products).

LED BENEFITS

Until recently, mercury arc lamps were the only sources capable of providing high intensity light suitable for UV photolithography exposure. Thanks to the advances in LED technology, UV-LEDs have become a very attractive alternative to the energy-consuming mercury lamps.

Along with the ecological and security aspects, the technical advantages of UV-LEDs as compared with traditional mercury lamps are numerous and significant for photolithography. A foremost advantage of UV-LEDs is that they operate with consistent emission for very long lifetimes. As a result, daily calibration and maintenance are not required. Furthermore, by being more energy efficient, LEDs have reduced heating, which greatly simplifies system cooling.

Benefits of UV-LED technology
long lifespan of LEDs, meaning no more consumable required
no daily calibration required, instantly stable illumination
instant-on, light is ON only during exposure, no mechanical shutter needed
low power consumption
limited heating, implying very low air cooling costs
no maintenance costs

Fig. 1: Stand-alone UV-LED exposure system • *The model shown is the UV-EXP150S. The control unit (see insert) is compatible with all models.*

UV-LED EXPOSURE SYSTEM

idonus has introduced a complete line of UV-LED exposure products. Our systems integrate the most effective UV-LEDs available on the market together with high-grade microlens arrays. They are fully assembled and controlled in-house.

Our design features a fully telecentric optics that provides reproducible and uniform illumination conditions over the whole exposure area – *i.e.*, highly homogeneous and stable intensity with very small divergence angles. This cutting edge optics ensures perfectly uniform exposure of the entire substrate, producing cured photoresists with straight sidewalls and enabling precise microstructuring of patterns with micrometer critical dimensions.

Fig. 1 is a photograph of one of our standard products. A simplified schematic of the optical system is shown in Fig. 2. The microlens array is the basis component of our light homogeneizer (also known as fly's eye condenser, or Köhler integrator). The collimation angle shown in the illustration (half-angle α) is a design parameter of particular interest for the user as it determines the sidewall angle of photoresist microstructures and gives indication on achievable critical dimensions.

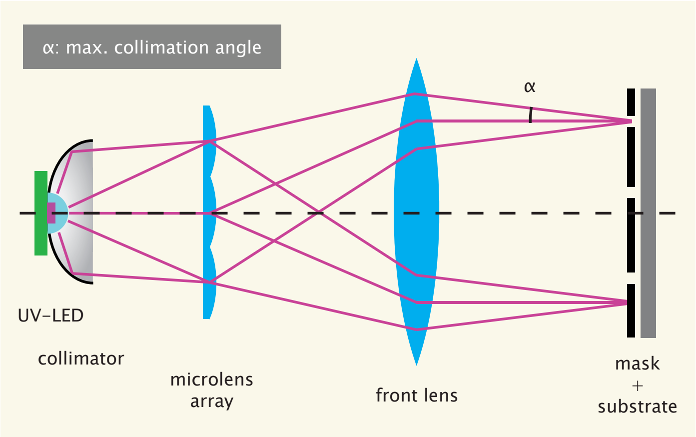


Fig. 2: Optical system (simplified) • *High uniformity of the illumination is achieved thanks to the use of a microlens array homogenizer.*

PERFORMANCES

Our UV-LED exposure system is available in several standard configurations that can be customized with a multitude of variations (*e.g.*, single or mixed wavelengths). As a manufacturer of special machines, idonus can also develop fully customized equipments according to client's specifications (*e.g.*, different exposure area, adapted equipment housing).

The main characteristics of our products are given in Table 1. A typical measurement performed during the calibration process is shown in Fig. 3: In the usable exposure area, irradiance inhomogeneity is lower than ±3%. The maximum collimation angle α which is illustrated in Fig. 2 is another important parameter that we systematically characterize. Data shown in Fig. 4 are typical results extracted from measurements performed on our model UV-EXP150S. To evaluate α, irradiance is measured as a function of the collimation angle: α corresponds to the FWHM (full width at half maximum). This threshold is commonly used to consider light energy effectively contributing to photoresist irradiation. Given the performance of our exposure system, about 95% of the energy is enclosed within the collimation angle.

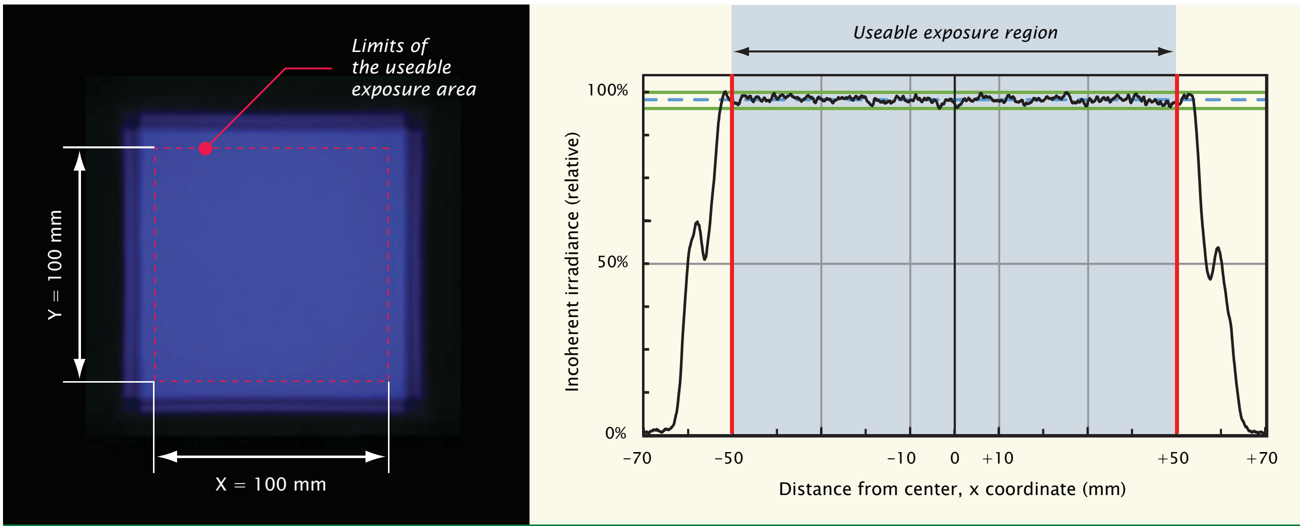


Fig. 3: Irradiance inhomogeneity • *Measurements show inhomogeneity lower than ±3%. Typical values extracted from our model UV-EXP100S (square illumination area of 100×100 mm²).*

Characteristics \ System type	UV-EXP150R	UV-EXP150S	UV-EXP200S	UV-EXP300S
Useful exposure area	∅ 150 mm	150×150 mm²	200×200 mm²	300×300 mm²
Wavelength (single or mixed)	365 nm and/or 385 nm / 395 nm / 405 nm *all models can be configured with UV-LEDs with multiple wavelength peaks*			
Irradiance (@385/395/405 nm)	50 mW/cm²	50 mW/cm²	30 mW/cm²	17 mW/cm²
Irradiance (@365 nm)	40 mW/cm²	40 mW/cm²	25 mW/cm²	12 mW/cm²
Irradiance inhomogeneity ±(max−min)/(max+min)	±3%	±3%	±3%	±3%
Maximum collimation angle (±α, FWHM)	±1.8°	±1.8°	±1.4°	±1°
Working Distance (WD)	350 mm	300 mm	400 mm	300 mm
	note that for all our models, other WD can be designed to address your specific needs			
External dimensions, H×W×D **(mm³)**	610×302×244	607×352×294	728×412×354	936×560×504

Table 1: Standard UV-LED exposure systems • *Typical specifications of our standard products that are optimized for different exposure areas.*

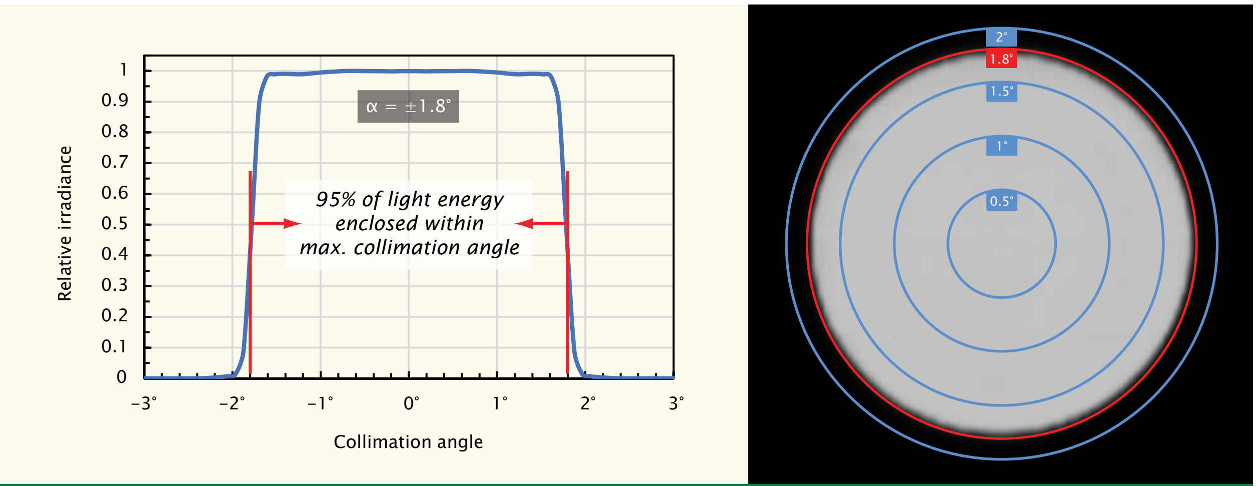


Fig. 4: Angular spectrum *• UV light is enclosed within the max. collimation angle (intensity threshold at FWHM, corresponding to 95% of light energy). Typical values extracted from our 150×150 mm² model (max. collimation angle of ±1.8°).*

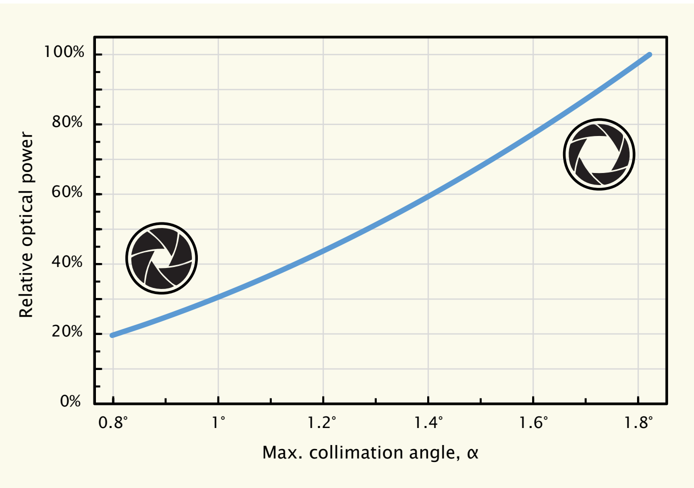


Fig. 5: Collimation angle can be adjusted with a diaphragm *• An integrated diaphragm can be used to reduce the collimation angle, at the expense of a reduced optical power.*

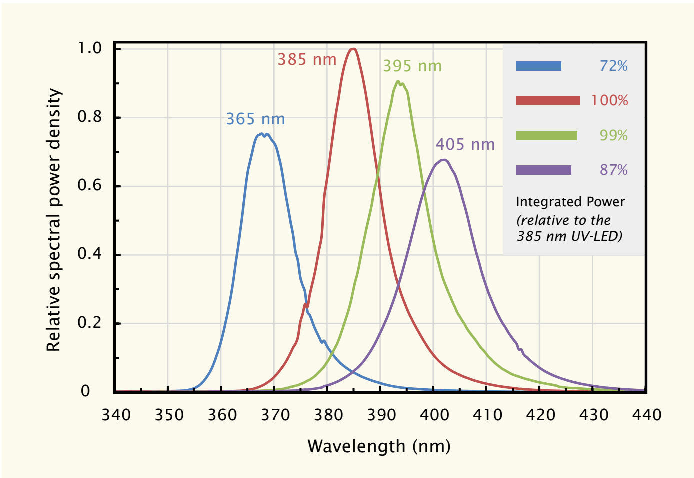


Fig. 6: UV-LEDs spectral power distribution *• These high-power LEDs can be combined to cover the UV spectrum between 360 and 410 nm.*

In option, for applications that require a smaller collimation angle, a diaphragm can be integrated in the optical system. This feature comes at the expense of a reduced optical power. The relationship between max. collimation angle and optical power is shown in Fig. 5. For example, if one needs to expose a square surface of 150×150 mm² with a collimation angle smaller than ±1.8°, series UV-EXP150S could be used with an additional diaphragm. In that case, the output optical power would be reduced according to the graph in Fig. 5.

UV-LED SPECIFICATIONS

We recommend the use of the 385 nm UV-LEDs which are the most powerful, as most photoresists are optimized for that wavelength. Nevertheless, as you may wish to mimic the UV spectrum of mercury arc lamps, other wavelengths are available, including 365 nm (i-line) and 405 nm (h-line). Mixed wavelengths are also possible.

In Fig. 6, we reproduce the LED spectrum characteristics with the different wavelengths that can be integrated in our system. The 405 nm (h-line) UV-LED can be used in combination with the 365 nm UV-LED (i-line) to produce a broadband exposure close to that of mercury arc lamps. The 385 nm and 395 nm UV-LEDs have higher power and may be used for optimum exposure performance.

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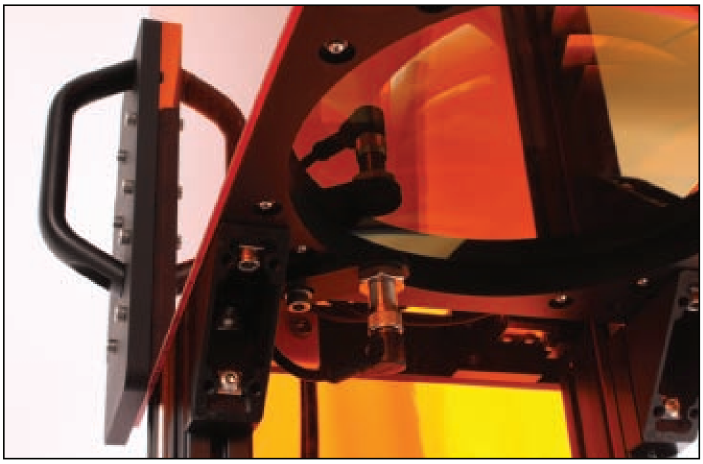
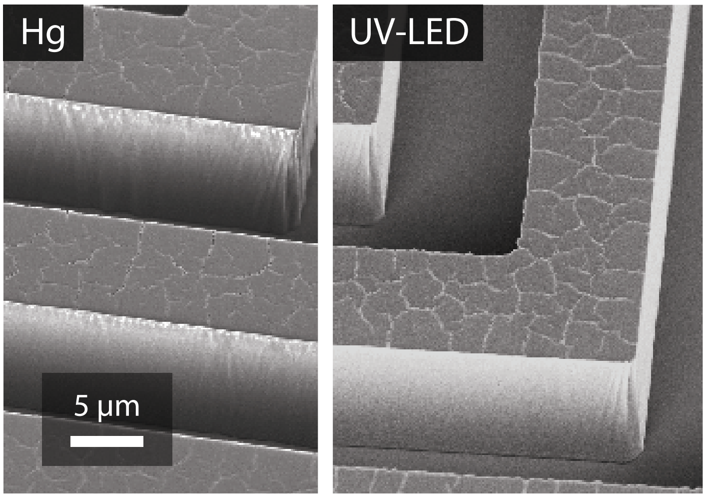


Detail view of the Gallium Phosphide (GaP) sensor mounted on model UV-EXP150R-SYS.

Highly homogeneous exposure area of 300×300 mm² is obtained with model UV-EXP300S.

UV-EXP200S-SYS : complete system with mechanical base and UV protection shield. Equipment configured with liquid cooling.



Comparative example of photolithography exposure results obtained with conventional Hg lamp (left) and our UV-LED exposure system (right). Results are essentially the same.

Creative engineering and manufacturing • Our engineering team is accustomed to develop products according to client's needs. In-house machining and assembling facilities shorten the time from concept to finished products.

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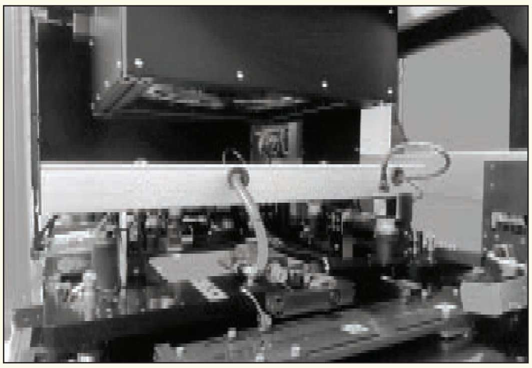
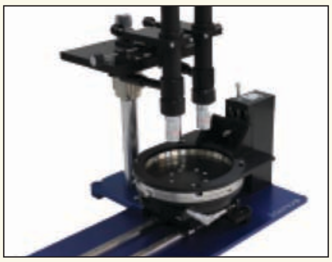
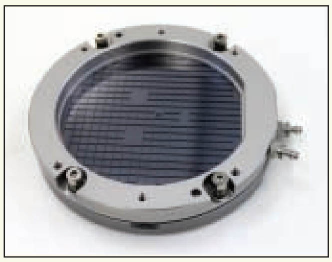


a customized UV-LED exposure system installed on a roll-to-roll machine



double image microscope



a model of wafer chuck

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