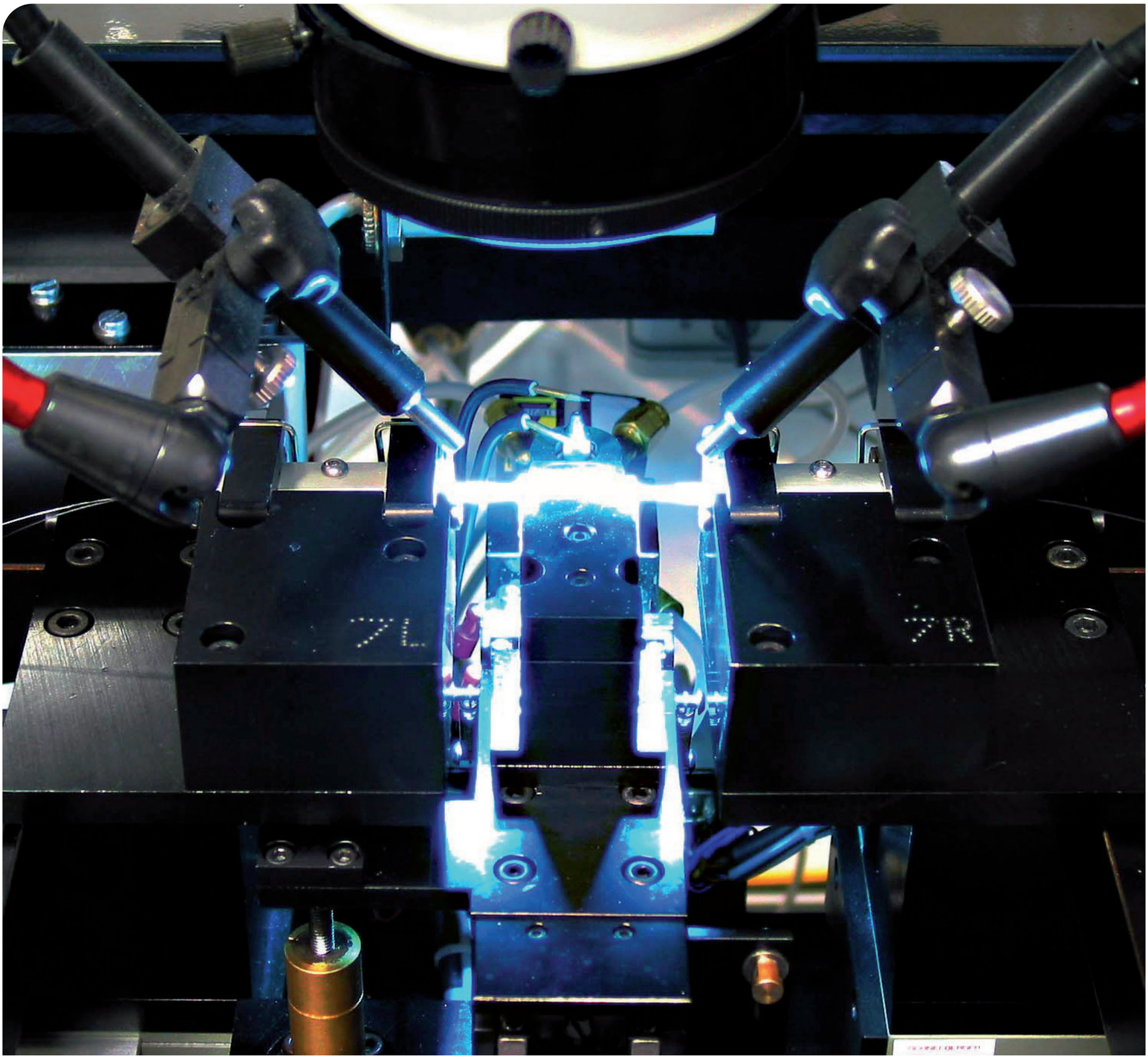


Basic Principles

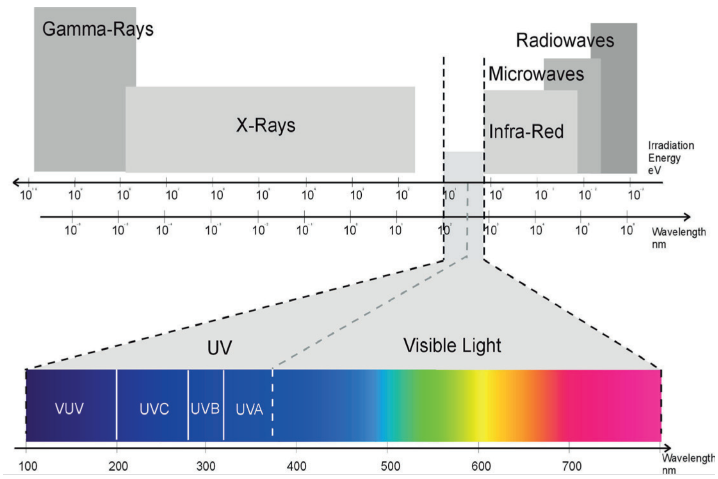
Fundamental principles of UV reactive manufacturing processes

The Basics – Fundamental principles of UV reactive manufacturing processes

While the UV systems technology and the appropriate chemistry have been developing continuously, the principle of irradiation curing has widely remained unchanged:
High-energy UV irradiation causes chemical curing of UV reactive coatings within seconds.

UV-Spektrum

The short-wave, high-energy UV irradiation in the spectrum between 200nm and 400nm is able to convert a liquid UV reactive substance into a solid film within a split second.

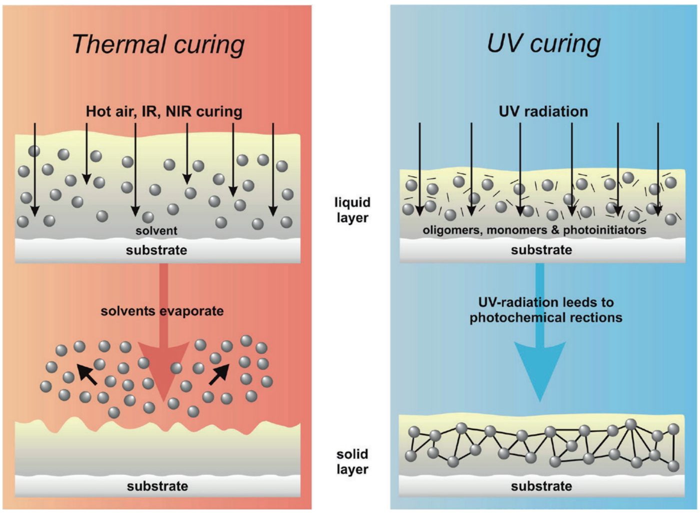


DIN 5031, part 7 classifies the UV range of the electromagnetic spectrum into four sub-groups, with significant characteristics in each.

UV range	Wavelength [nm]	Photon energy [eV]	Characteristics	Field of application
visible light	780 - 380	1,60 - 3,26		adhesives
UV-A	380 - 315	3,26 - 3,94	deep curing	inks or coatings
UV-B	315 - 280	3,94 - 4,43		varnishes
UV-C	280 - 200	4,43 - 6,20	surface curing	sterilization
V-UV	200 - 100	6,20 - 12,4	absorption by O_2	no application for UV curing

Chemical curing

Contrary to a thermal drying process, which works by evaporating the solvent contained in the coating, curing initiates a chemical reaction within the coating compound, which leads to a polymerization reaction.



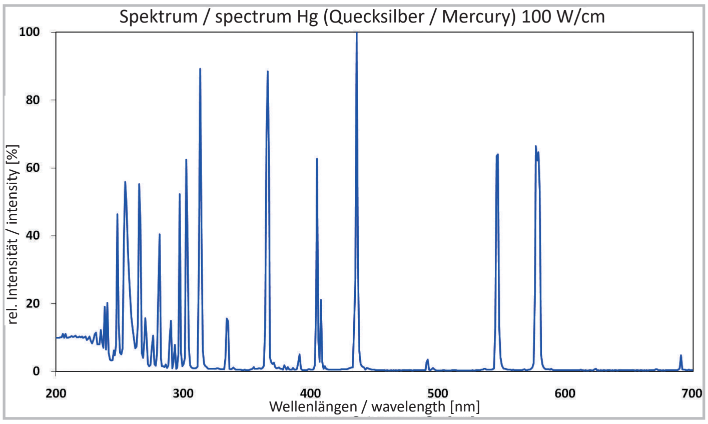
As soon as the reaction is activated by the UV irradiation the fluid layer "cross-links" to an inert film within a split-second. The majority of UV coatings offer a 100% coating residual, i.e. they cure almost without loss of coat thickness or VOC-emissions.

The irradiation-sensitive element of the coating formulation is the photo initiator. Influenced by the UV irradiation, the photo initiator - at a radical polymerization - forms free radicals, which are able to split the double bonds within the oligomeres and monomers. This is the start of a polymerization reaction, which transforms the fluid varnish film into a three-dimensional structure.

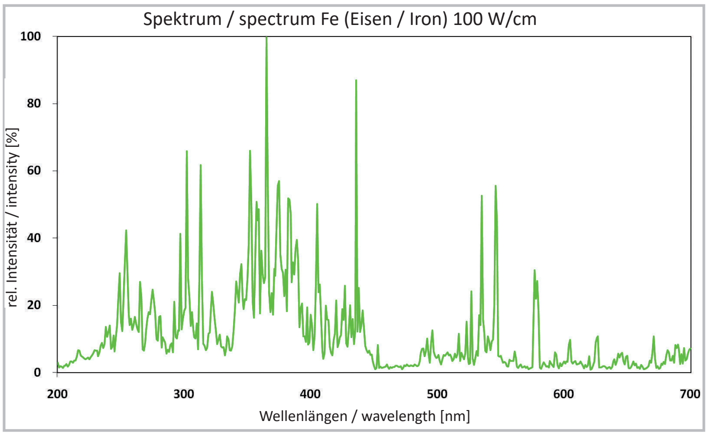
UV-Irradiation

UV curing systems medium pressure lamps

The heart of a UV discharge lamp is the silica tube with fused-in electrodes on both ends. When the lamp ignites, the high voltage arc generates a plasma between the electrodes. This Plasma emitts the typical UV spectrum of a medium pressure lamp.



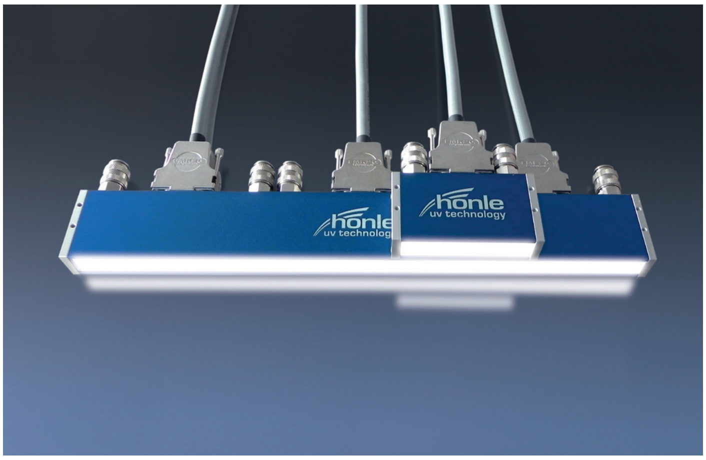
By adding different dopings to the mercury, e.g. iron or gallium, the wavelength can be shifted into a longer-wave range within the respective spectrum. Due to the chemistry the curing parameters can be optimized by the use of a doped spectrum.



LEC

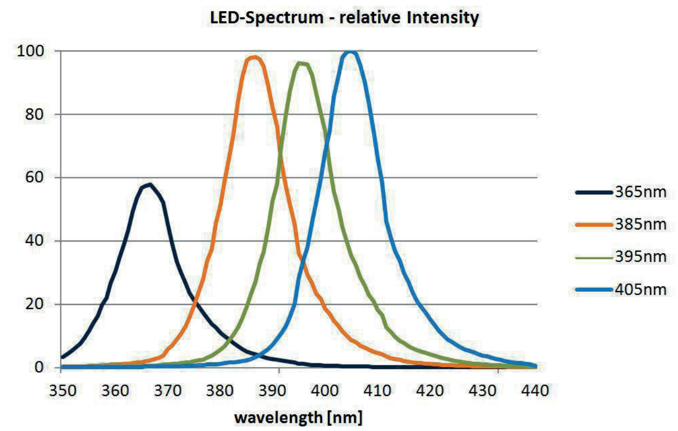
As one popular example "Low Energy Curing" has to be mentioned: a curing application for sheetfed offset presses which is based on using high reactive UV inks. A suitable adjustment between inks and iron doped UV radiators allows printers to profit from fastest throughput times and a significant reduction of energy consumption.

UV-LED



Powerline

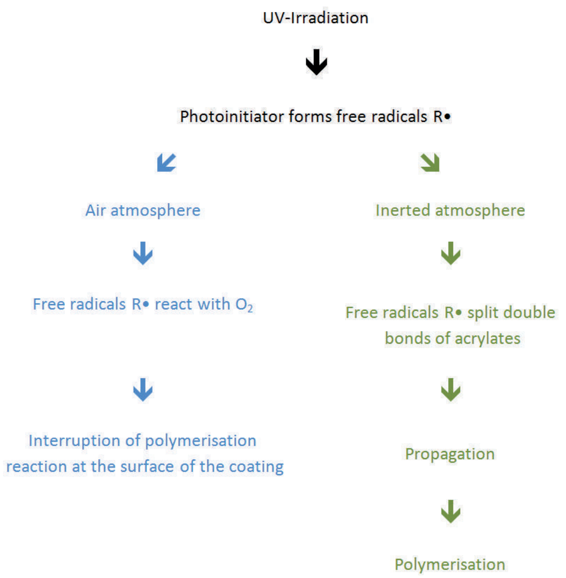
Compared to conventional discharge lamps UV-LEDs do not produce a broad UV spectrum, but a narrow band with specific emission peak. Furthermore LEDs do not emit IR irradiation.
When using LEDs even temperature-sensitive materials can be irradiated, as only marginal heat affects the substrate. The different spectra ensure safe and fast curing.



LEDs are characterized by a very long life cycle. Typical application fields for LED curing are in the bonding, potting and digital printing industries.

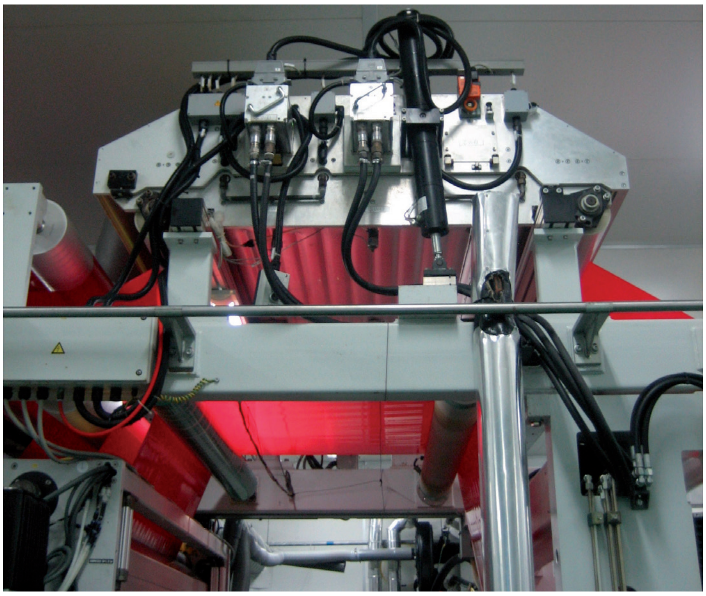
Inertization

At an inertization process the oxygen (O_2) in the irradiated area is displaced by an inert gas, usually nitrogen (N_2).



The generated radicals out of the photo initiators preferably react with O_2 molecules in the atmospheric oxygen, which can lead to insufficient surface cross-linking. By eliminating the atmospheric oxygen with inertization, the polymerization process can run undisturbed.
The positive effects of inertization on the production process are various:

- excellent surface-curing and outstanding characteristics
- higher cross-linking levels, no post-curing
- less UV irradiation required and increased production speed
- lower amounts of photo initiator levels in UV ink, thus cost savings
- less migration because of significantly lower amounts of photo initiators and complete curing
- smell reduction
- less yellowing
- even „problematic colours“ like full surface white can run at high speeds
- reduced ozone production



Xiamen Changtian

Terminology

The performance of an UV bulb is classified by the specific lamp power in W/cm. Typical values for a specific lamp power are 80W/cm to 200W/cm. This classification indicates the electrical power supplied to the bulb per cm length. The power specification W/cm offers no real meaningful indication of the power or energy density actually present at the curing surface. Therefore information such as reflector geometry or distance to the substrate has to be considered. The actual existing intensity and energy values on the surface cannot be calculated, they must be measured!

Here the intensity or irradiancy refers to the measured power in Watt [W] per surface [cm ²].

Intensity I in [mW/cm²]

The dose or energy density is indicated in joule [J] per surface [cm ²]. It results from the integral of the intensity, thus it considers the irradiation period.

Energy density E in [mw*s/cm²] = [mJ/cm²]

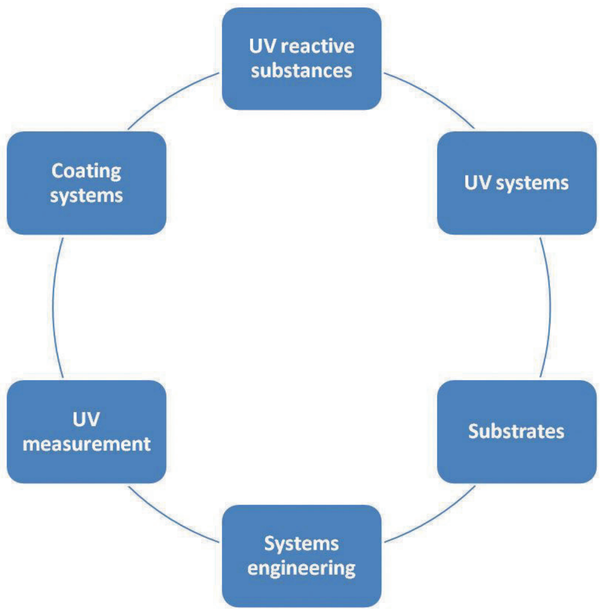
In order to be able to determine a UV process accurately, both data as well as information about the measuring system are necessary.

Advantages of UV curing

Fast curing within seconds	→	Immediate processing and distribution possible, fast quality control
Usage of solvent-free coating systems	→	Marginal VOC emission
No need for drying ovens to evaporate solvents	→	No afterburning or solvent recycling necessary ⇩ Energy saving
Single-component systems	→	No pot life, less waste
Highly cross-linked systems	→	Reliable chemical and physical resistance

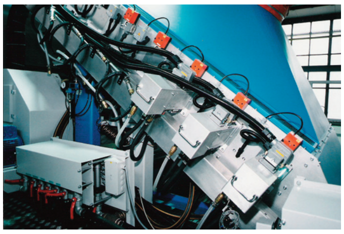
Typical application fields for the utilization of UV technology are in sheet-fed offset printing, inkjet printing, web offset, flexo printing, in the coating and finishing, bonding and potting for electronic and opto-electronic components, in the surface sterilization, sun simulation and photovoltaic industries.
Each industry needs special UV reactive substances, whose characteristics meets the requirements of the specific application. The chemical industry resolved this issue and over recent years has developed a broad product range of UV reactive varnishes, inks and adhesives.
UV technology grew out of its infancy in the furniture industry a long time ago. Today it is indispensable for high technology applications.

This interaction makes UV curing an unique, significant and reliable process.



Wide variety of UV applications


Sheet-fed offset

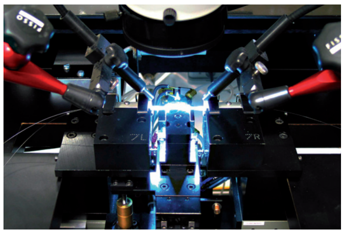

Converting and siliconization

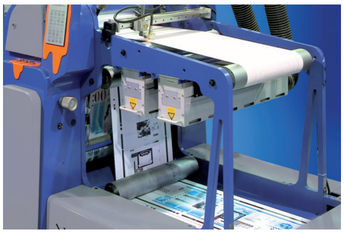

Disinfection

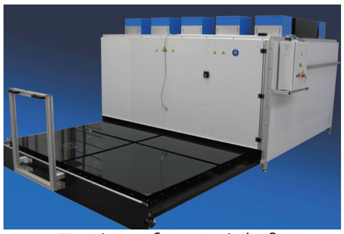

Inkjet

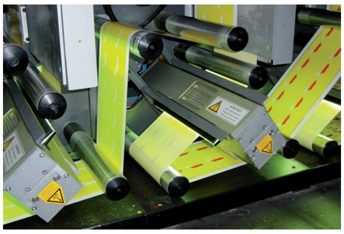
areas of UV application

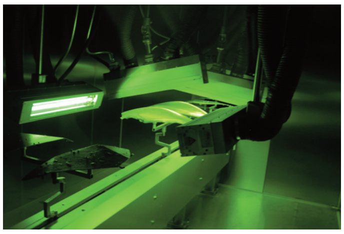
- Curing inks and coatings
- Simulation of natural sunlight
- Curing adhesives and plastics
- Surface disinfection


Curing adhesives and plastics


Web offset


Testing of materials & photovoltaic


Flexo print


Finishing / Coating


Fluorescence test