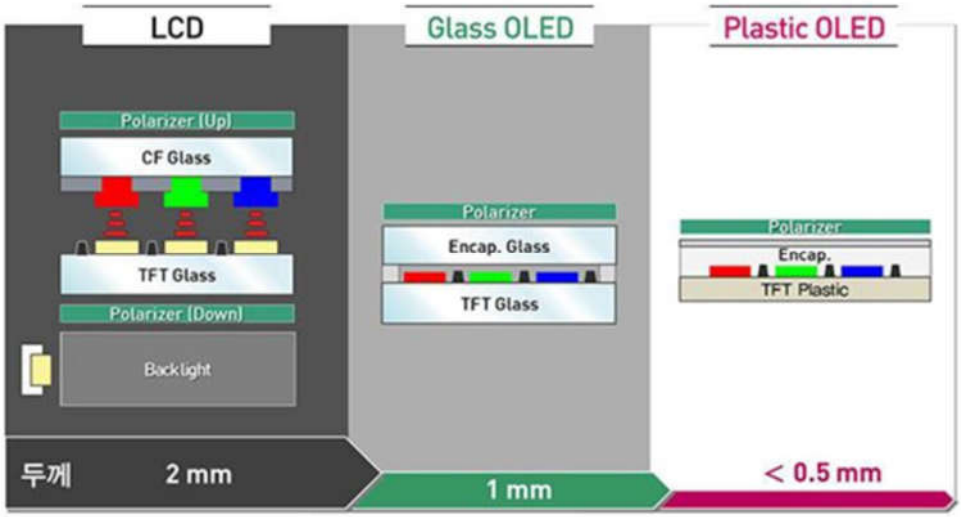
Case Study: Excimer Laser Annealing for Brilliant AMOLED Displays

Excimer laser annealing is key to mass production of polysilicon substrates for high-performance mobile displays. Vyper/LineBeam-technology supplies the global demand. The smartphone and tablet revolution has spurred the broad-scale use of polysilicon backplanes for razor-sharp mobile LCDs and for self-illuminating OLED displays up to the largest diagonal. The enabling production infrastructure has been created in the garb of the new Vyper/LineBeam-system for excimer annealing.

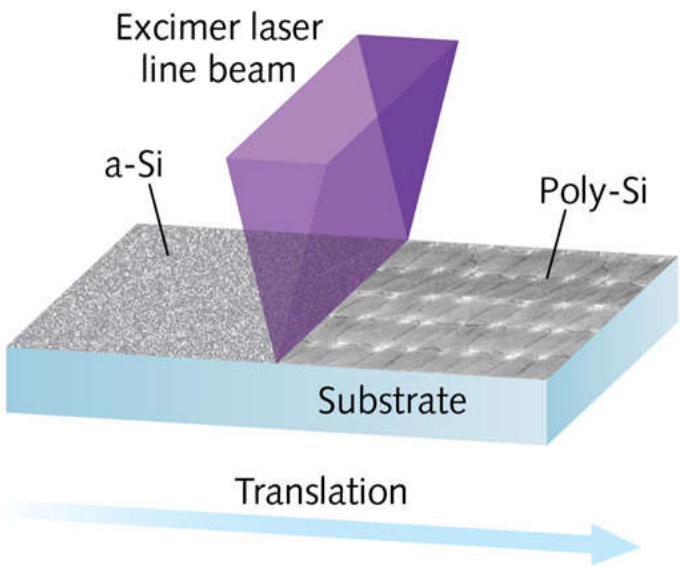
Mobile displays have become ubiquitous in our information- and knowledge society. In times of digitalized information content, mobile internet access has become the basis of our communication culture and our smartphones or tablets have become always available windows to the world. Their displays with touch screen functionality are made up of pixels similar to the boxes on grid paper. The higher the pixel number of a display the more-detailed the visual content can be displayed.



Today, the standard specifications of smartphone displays include Full HD resolution, i.e. over 2 Million pixels which, depending on the respective display diagonal, translates into pixel densities of beyond 400 ppi (pixels per inch). The general trend of steadily increasing pixel densities necessitates shrinking dimensions of the pixels and as well their accompanying thin-film transistors (TFTs). Conventional TFTs based on amorphous silicon reach their performance limit when the pixel densities of liquid crystal displays (LCDs) cross the 300 ppi mark. The magic word is „polysilicon“. TFTs based on polysilicon have an over 200 times better current conductivity and a stable switching behaviour, which is why their use is equally imperative in case of the self-illuminating OLED-displays.
The significantly smaller polysilicon-TFTs support denser pixels and let more backlight pass through the display. The power consumption for backlighting can consequently be reduced. Furthermore, driver circuitry can be integrated on the display enabling fewer connections and thus a narrow bezel design.

The global number of smartphone users is expected to increase significantly amounting to as much as two billion users. Demand for polysilicon is further driven by the increasing market penetration of high pixel density mobile LCD and OLED devices. Producing the vital crystalline backplanes for the high-volume mass market is achieved with the latest-generation of excimer laser annealing systems.

The one of a kind Vyper/LineBeam-technology allows the production of the polysilicon-layer on large-format glass substrates ranging from Gen 6 to Gen 10 sizes. It generates a long line of pulsed laser light at a wavelength of 308 nm which moves along a glass carrier coated with amorphous silicon.



On account of the short UV wavelength and the short laser pulse duration in the nanosecond regime the energy of the line beam focus is selectively applied to the very thin silicon layer rather than in the adjacent heat-sensitive display glass. After all, the polysilicon layer is 2,000 times thinner than a hair, explains Dr. Ralph Delmdahl, Product Marketing Manager with Coherent in Goettingen. The amorphous starting material melts and crystallizes right behind the laser line the polycrystalline silicon layer. This recrystallization process is known as excimer laser annealing.

The throughput of a Vyper/LineBeam-system is about 15,000 square meters of polysilicon per month - equivalent to the size of three soccer pitches and sufficient for two million 5-inch Full HD displays.

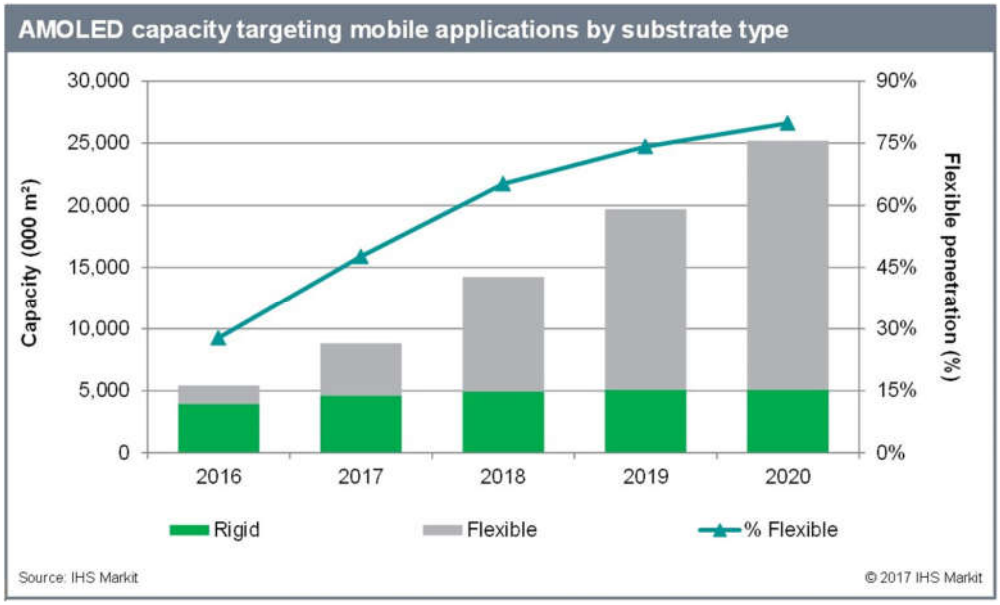
The unique conceptual approach of Vyper/LineBeam-technology has lifted excimer laser annealing as the only practicable method of industrial generation of polysilicon to the level of mass manufacturing.

It is based on multiple oscillators each delivering 600 W average power and 1 Joule pulse energy. A patented high voltage switching device ensures temporally synchronized light pulse emission of the two oscillators with an accuracy of 2 ns. The result is the multi-beam multi-kilowatt excimer laser „Vyper“. Each laser beam of the Vyper enters the optical delivery module „LineBeam“ and all beams are successively mixed, expanded and spatially superimposed. In the final stage, a combined line beam is projected onto the substrate as a homogeneous line beam with dimensions as large as 1,500 mm x 0.4 mm.

Today, some 200 Vyper/LineBeam-systems have been installed at all major display factories. They provide the global production capacity of polysilicon-backplanes which represent a vital ingredient of the high-resolution mobile displays of all manufacturers.

The formula is simple: Without Vyper/LineBeam-technology no polysilicon-based TFTs. At this point, I like to quote Thomas Friedman: „Big breakthroughs happen when what is suddenly possible meets what is desperately necessary", says Dr. Ralph Delmdahl.

Market researchers indicate that the demand for polysilicon backplanes will continue to rise in the coming years. Currently, the demand for Vyper/LineBeam-systems for polysilicon backplane production is maintained primarily by the still booming smartphone market. Here, the pixel count has quadrupled in just a few years from 1,920 x 1,080 pixels (Full HD) to 3,840 x 2,160 pixels (Ultra HD) and higher. This megapixel trend is now also spreading to the tablet displays which already feature pixel densities beyond 300 ppi shifting them into the realm, where polysilicon adopts its enabling character.



And the next wave of demand is already there: Market researchers agree that the wide adoption of the even more brilliant and energy saving OLEDs in mobile displays will drive the next five years of continuing market growth and capacity expansion in the industry. With market extension to more display segments and next generation display technologies such as, flexible displays, Quantum Dot or Micro-LED based displays already looming on the horizon, the next decade of success for excimer line beam systems is well-conditioned.

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