

Focal- π Shaper in Photovoltaics

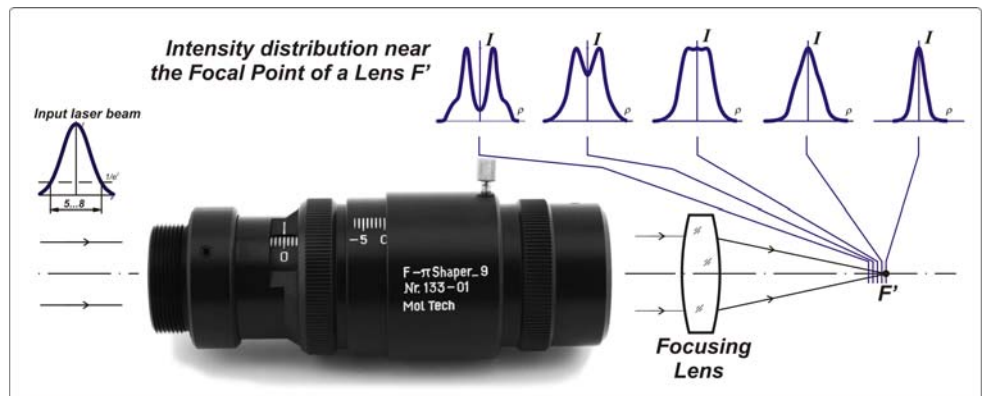
Lasers become more and more popular in production of various solar cells finding application in such technologies like:

- Edge Isolation,
- Vias Drilling,
- Patterning in Thin-Film cells (P1, P2 and P3 structuring),
- Edge Delete in Thin-Film cells,
- Marking,

and bringing increasing the productivity, quality and other features in production process.

Performance of above mentioned laser technologies can be seriously improved by applying the Laser Beam Shaping technique, for example, transformation of a beam intensity profile from Gaussian to so called flattop (uniform) distribution. This optical transformation helps to improve a trench profile in sense of steeper walls and reaching flat bottom, reduce drastically the HAZ (heat affected zone) and increase the productivity of material processing due to more efficient usage of the laser energy (see the details at http://www.pishaper.com/shaping_system.php).

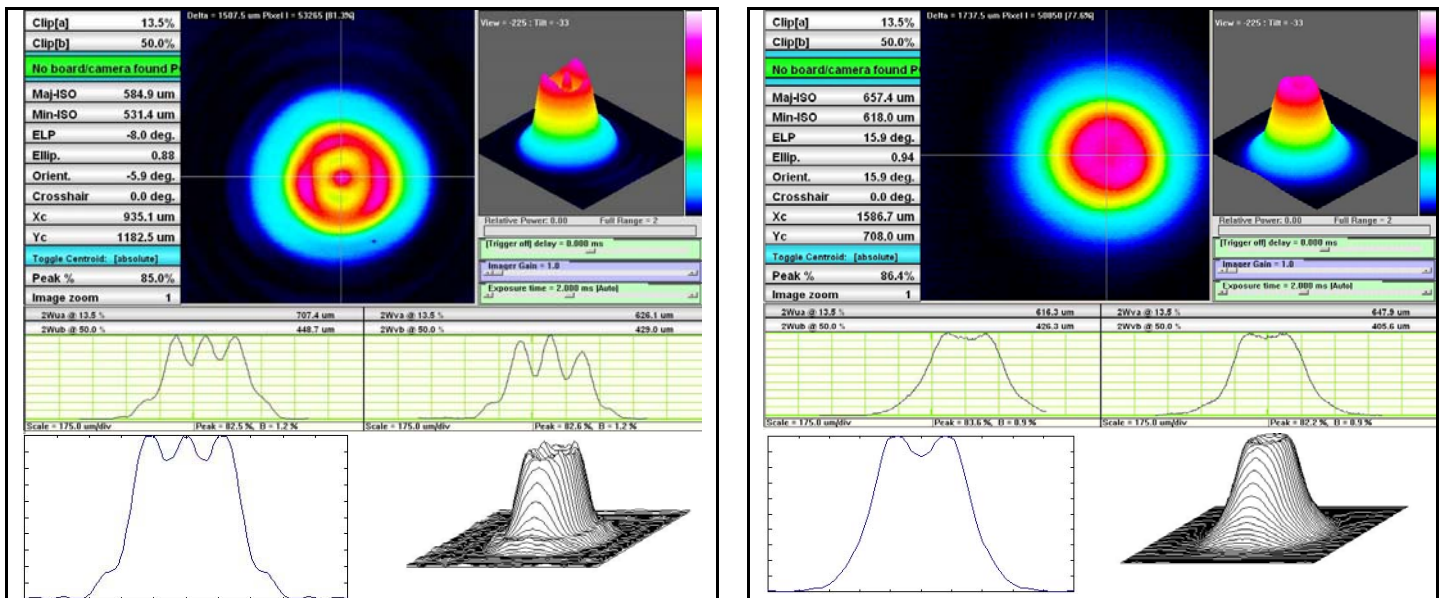
Just this transformation is realized by the refractive beam shapers **Focal- π Shaper** (or **F- π Shaper**) - intended to work with lasers of different wavelengths and create flattop, donut and other intensity distributions for beams focused by a diffraction limited lens to spots below 100-200 micron.



The series of **F- π Shaper** models is a part of a family of refractive beam shapers realizing so called field mapping optical approach and having the trade name **π Shaper**.

Intensity profiles of focused beams under various F- π Shaper settings

(Courtesy of Altechna, Lithuania)



Input beam diameter 6 mm

Input beam diameter 4.2 mm

The operational principle presumes applying of a focusing lens after the **F- π Shaper**.

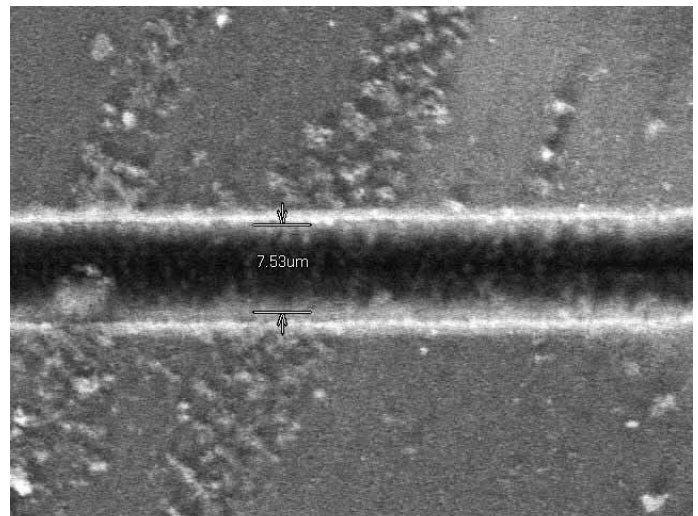
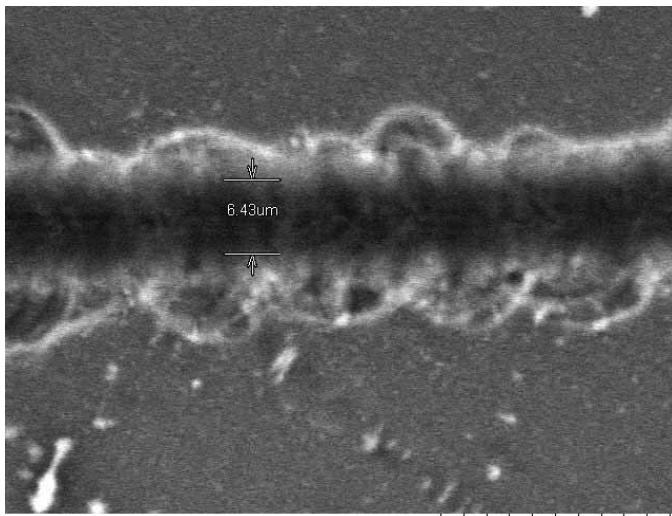
There can be a lens of any type: an F-theta lens, any kind of telecentric lens or focusing lens. The most important feature of the lens is that it has to be diffraction limited one, in other words, it shouldn't implement any wave aberration over whole working field. This is an essential condition for proper operation of the **F- π Shaper**.

Detailed description of the **F- π Shaper** models is presented at http://www.pishaper.com/f_shaper.php.

Effect of applying the *F- π Shaper* in scribing laser technologies is illustrated on below pictures showing results of scribing of glass with a femtosecond laser, wavelength 1064 nm, M^2 about 1.2.

Laser scribing with a shortpulse laser

(Courtesy of Altechna, Lithuania)



TM-1000_0093 2007/12/10 15:44 20 μ m

TM-1000_0113 2007/12/10 18:14 20 μ m

with Gaussian beam

Features:

- irregular trench edges,
- wide HAZ.

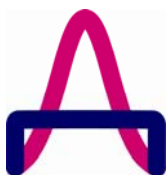
with *F- π Shaper 9_1064*

Features:

- even trench edges,
- steep walls,
- almost without HAZ.

Other features of the scribing of thin-film solar cells with using beam shaping optics on the base of the *F- π Shaper 9_1064* are discussed in details in the paper:

Alexander Laskin, Vadim Laskin (2010)
Refractive field mapping beam shaping optics: important features for a right choice (M1301)
ICALEO 2010, September 27 – 30, 2010, Anaheim, CA, USA.



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